DOCUMENT RESUME

ED 219 615 CE 033 348

TITLE	Military Curriculum Materials for Vocational and Technical Education. Materials Testing and Quality Control Soils, 3-28.
INSTITUTION	Naval Construction Training Center, Port Hueneme, Calif.; Ohio State Univ., Columbus. National Center for Research in Vocational Education.
SPONS AGENCY	Office of Vocational and Adult Education (ED), Washington, DC.
PUB DATE	[82]
NOTE	443p.
EDRS PRICE	MF01/PC18 Plus Postage.
DESCRIPTORS	Behavioral Objectives; Course Content; Field Instruction; Group Instruction; Individualized Instruction; Laboratory Procedures; *Learning Activities; Lesson Plans; Postsecondary Education; *Quality Control; *Soil Science; Technical Education; *Units of Study; Vocational Education
IDENTIFIERS	Military Curriculum Project

ABSTRACT

This instructional package on material testing and quality control of soils has been adapted from military curriculum materials for use in technical and vocational education programs. This short course presents basic information on soils as well as exploration, field identification, and laboratory procedures that will enable students completing the course to explore, identify, classify, and stabilize soils. The course contains two units totaling 64 hours of classroom and practical instruction. Unit 1, Introduction and Safety, contains a 1-hour lesson introducing the course and discussing safety procedures. Unit 2, Soils Testing, contains 10 lessons covering 20 hours of classroom and 43 hours of practical instruction. The course materials consist of a single document containing both teacher and student materials. The teacher materials provided include an introduction; outline of instruction; outline of training objectives; lists of texts, references, tools, equipment, materials, training aids and devices, and training equipment; a master schedule; and lesson plans. The lesson plans contain an outline of instruction and activities for the teacher and students. Student materials consist of five information sheets, three job sheets, one sample problem, one practice problem, and eight worksheets. The materials are suitable for both group and individualized instruction. (KC)

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MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

The National Center Mission Statement

The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

FOR FURTHER INFORMATION ABOUT
Military Curriculum Materials
WRITE OR CALL

Program Information Office
The National Center for Research in Vocational Education
The Ohio State University
1960 Kenny Road, Columbus, Ohio 43210
Telephone: 614/486-3655 or Toll Free 800/848-4815 within the continental U.S. (except Ohio)

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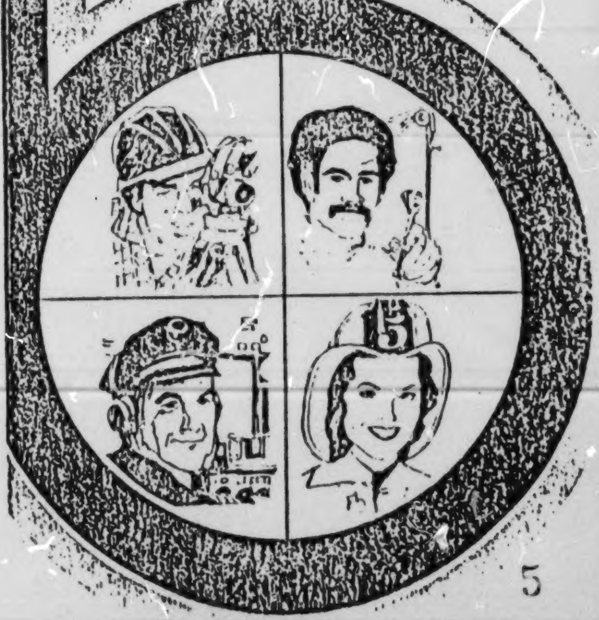
Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

The National Center for Research in Vocational Education



Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

MIDWEST
Robert Patton
Director
1515 West Sixth Ave.
Stillwater, OK 74704
405/377-2000

NORTHEAST
Joseph F. Kelly, Ph.D.
Director
225 West State Street
Trenton, NJ 08625
609/292-6562

NORTHWEST
William Daniels
Director
Building 17
Airdustrial Park
Olympia, WA 98504
206/753-0879

SOUTHEAST
James F. Shill, Ph.D.
Director
Mississippi State University
Drawer DX
Mississippi State, MS 39762
601/325-2510

WESTERN
Lawrence F. H. Zane, Ph.D.
Director
1776 University Ave.
Honolulu, HI 96822
808/948-7834

ENGINEERING AID SCHOOL, MATERIALS TESTING AND QUALITY CONTROL SOILS

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ENGINEERING AID SCHOOL, MATERIALS TESTING AND QUALITY CONTROL SOILS

Classroom Course 3-28

Developed by:
United States Navy

Development and Review Dates
August 1975

D.O.T. No.:
005.081

Occupational Area:
Building and Construction

Target Audiences:
Grades 11-adult

Print Pages:
268

Cost:
$5.25

Availability:
Military Curriculum Project, The Center for Vocational Education, 1960 Kenny Rd., Columbus, OH 43210

Contents:	Type of Materials:						Instructional Design:				Type of Instruction:	
	Lesson Plans:	Programmed Text:	Student Workbook:	Handouts:	Text Materials:	Audio-Visuals:	Performance Objectives:	Tests:	Review Exercises:	Additional Materials Required:	Group Instruction:	Individualized:
Unit 1.1 – Introduction and Safety												
1.1.1 – Introduction and Safety	●						●	★		★	●	
Unit 1.2 – Soils Testing												
1.2.1 – Introduction to Soils	●				★		●	★		★	●	
1.2.2 – Soils Exploration	●			●	★		●	★		★	●	●
1.2.3 – Soils Classification	●			●	★		●	●		★	●	●
1.2.4 – Field Identification of Soils	●			●	★		●	●		★	●	●
1.2.5 – Laboratory Classification of Soils	●			●	★		●	●		★	●	●
1.2.6 – Field Evaluation of Soils	●				★		●	●		★	●	●
1.2.7 – Laboratory Evaluation of Soils	●			●	★		●	●		★	●	●
1.2.8 – Soils Exploration Report	●			●			●	●		★	●	●
1.2.9 – Soils Stabilization Agents	●			●	★		●	●		★	●	●
1.2.10 – Soils Stabilization (Design Procedures and Control)	●				★	★	●	★		★	●	

★ Materials are recommended but not provided.

Expires July 1, 1978

Course Description

Students completing this short course will be able to explore, identify, classify, and stabilize soils. The course presents basic information on soils as well as exploration, field identification, and laboratory procedures.

This course contains two units totaling 64 hours of classroom and practical instruction. Unit 1.1–**Introduction and Safety** contains a one hour lesson introducing the course and discussing safety procedures. Unit 1.2–**Soils Testing** contains ten lessons covering 20 hours of classroom and 43 hours of practical instruction. The lesson titles and hours are listed below:

1.2.1	Introduction to Soils (2 hours classroom)
1.2.2	Soils Exploration (2 hours classroom, 4 hours practical)
1.2.3	Soils Classification (4 hours classroom, 3 hours practical)
1.2.4	Field Identification of Soils (2 hours classroom, 4 hours practical)
1.2.5	Laboratory Classification of Soils (2 hours classroom, 8 hours practical)
1.2.6	Field Evaluation of Soils (2 hours classroom, 8 hours practical)
1.2.7	Laboratory Evaluation of Soils (2 hours classroom, 10 hours practical)
1.2.8	Soils Exploration Report (1 hour classroom, 4 hours practical)
1.2.9	Soils Stabilization Agents (2 hours classroom, 2 hours practical)
1.2.10	Soils Stabilization (Design Procedures and Control) (1 hour classroom)

This course consists of a single document containing both teacher and student materials. The teacher materials provided include an introduction; outline of instruction; outline of training objectives; lists of texts, references, tools, equipment, materials, training aids and devices, and training aid equipment; a master schedule; and lesson plans. The lesson plans contain an outline of instruction and activities for the teacher and students. Student materials include five information sheets, three job sheets, one sample problem, one practice problem, and eight worksheets.

The text for this course is the Navy manual, *Material Testing, NAVFAC MO-330* which is not provided. Four military manuals and two commercial publications are recommended as references, as well as the following film:

SO!001	Soil-Cement Inspection and Field Control (20 min.)

3-28

SEABEES

SPECIAL CONSTRUCTION BATTALION TRAINING

ENGINEERING AID SCHOOL
440.2A MATERIAL TESTING AND QUALITY CONTROL
SOILS

AUGUST 1975

DEPARTMENT OF THE NAVY
NAVAL CONSTRUCTION TRAINING CENTER

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HOW TO USE INSTRUCTOR GUIDES

Instructor Guides are provided for each topic and include supporting instructional materials and aids identified by the topic number and preceded by a letter code designation. The letter code key is as follows:

AS - Assignment Sheet
JS - Job Sheet
IS - Information Sheet
CN - Class Notes
OS - Operation Sheet
T - Test
FT - Final Test
TR - Transparency
DS - Diagram Sheet
PS - Problem Sheet
PT - Pretest
PE - Performance Evaluation
WS - Work Sheet
G - General (give a definition of item)

A complete listing of all supporting materials and aids is documented with full descriptive titles in Annex.

The instructor guides are intended to be used as master lesson plans subject to personalization by the individual instructor. In all cases, it is expected that the instructor will study the references in preparation for annotating the guide. It is also expected that each instructor will develop an appropriate introduction for each topic that will (1) create interest, (2) show the value of the topic to the student, (3) relate the topic to previous and future topics in the course, and (4) communicate the learning objectives to the student. Well prepared introduction will then provide the important motivational conditioning to establish readiness and effect for learning appropriate to each topic.

The first page of each instructor guide contains the following functional information:

1. Topic of lesson.
2. Time in periods
3. References.
4. Instructional Materials.
5. Instruction Aids.
6. Objectives (Terminal and Enabling).
7. Topic criterion test (as applicable).
8. Homework assignment (when applicable).
9. Tools and materials.

The pages following page 1 of each instructor guide provide in a three-column format the teaching/learning procedures for conducting the lesson. The left hand column includes the outline of instructional content required by the objectives; the center column includes recommended instructor activities or methodology; the right hand column contains recommended student learning activities.

While the methodology and student learning activities documented in each instructor guide have been tested and proven to be effective for the lead school, those schools implementing this curriculum are encouraged to exercise creativity in designing learning exercises and conceiving methods and techniques to meet course objectives.

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COURSE DATA PAGE

COURSE MISSION: To train selected Engineering Aids in the knowledge and technical skills defined by the Personnel Readiness and Capability Program for Engineering Aid Skill 440.2A.

PERSONNEL AND RATINGS ELIGIBLE: EA (E-3 thru E-6)

OBLIGATED SERVICE: N/A

NOBC/NEC: N/A

PHYSICAL REQUIREMENTS: N/A

SECURITY CLEARANCE REQUIRED: None.

PREREQUISITE TRAINING AND/OR BASIC BATTERY TEST SCORE REQUIRED: Materials Testing and Quality Control Soils Testing.

RELATED TRAINING: None

FOLLOW-ON TRAINING: Materials Testing and Quality Control, 440.2B (Bitumenious) and 440.2C (Concrete).

GRADING WEIGHT FACTORS: Performance of tasks throughout the course will be strictly on a Go/No Go basis.

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OUTLINE OF INSTRUCTION

TOPIC	Unit 1.1	CLASS	PRACT	TOTAL	PAGE
	Introduction and Safety				
1.1.1	Introduction and Safety	1	0	1	3
		1	0	1	
	Unit 1.2				
	Soils Testing				
1.2.1	Introduction to Soils	2	0	2	3
1.2.2	Soils Exploration	2	4	6	3
1.2.3	Soils Classification	4	3	7	4
1.2.4	Field Identification of Soils	2	4	6	4
1.2.5	Laboratory Classification of Soils	2	8	10	4
1.2.6	Field Evaluation of Soils	2	8	10	4
1.2.7	Laboratory Evaluation of Soils	2	10	12	5
1.2.8	Soils Exploration Report	1	4	5	5
1.2.9	Soils Stabilization Agents	2	2	4	5
1.2.10	Soils Stabilization (Design Procedures and Control)	1	0	1	5
		20	43	63	

* Total Periods Classroom: 21
* Total Periods Practical: 43
Total Hours for Course: 64
Total Weeks for Course: 2 Weeks

* All periods represent 60 minutes of actual instruction

OUTLINE OF TRAINING OBJECTIVES

Unit 1.1 INTRODUCTION AND SAFETY Contact Hours: 1

Terminal Objective: Upon completion of this unit the student will have registered for the course, received text books, complied with NAVCONSTRACEN and CBC regulations governing the reporting and fighting of fires which pertain to him as a SCBT student.

Topic 1.1.1 INTRODUCTION AND SAFETY Contact Hours: 1

Enabling Objectives: Upon completion of this topic the student will be able to answer orally specific questions pertaining to the mission, regulations and organization of the command, and the method of reporting and fighting fires as established by NAVCONSTRACEN and CBC regulations. This topic is not meant to be disqualifying.

Unit 1.2 SOILS TESTING Contact Hours: 63

Terminal Objective: Upon completion of this unit each student will have explored, identified, classified and stabilized soils. Conditions, standards and procedures for each of the related topics leading to the successful completion of this terminal objective shall be as set forth in each topic.

Topic 1.2.1 INTRODUCTION TO SOILS Contact Hours: 2

Enabling Objectives: Upon completion of this topic each student will be able to define the "soil" and its origin based upon physical characteristics, particle size and location. Instructor guidance, class notes and student texts may be utilized in performing the requirements of this topic. All student responses will be written and 100% accurate after checking by the instructor. This topic is not meant to be restricting.

Topic 1.2.2 SOILS EXPLORATION Contact Hours: 6

Enabling Objectives: Upon completion of this topic each student while working as a member of a team (not to exceed four (4) members) will be able to gather information of engineering significance through soils exploration. This will be done by employing planning criteria, sampling methods and soil profile development outlined in this topic instructor guide and NAVFAC MO-330, Material Testing. This topic will be worked in conjunction with topic 1.2.4, "Field Identification of Soils". Instructor guidance, class notes and student texts can be used in the performance of this topics requirements. Each student will be 100 percent accurate for technique and procedures of soils exploration. As a class all exploration results should conform with differences being resolved through group discussion.

Topic 1.2.3 SOILS CLASSIFICATION Contact Hours: 7

Enabling Objectives: Upon completion of this topic each student will be able to; given hypothetical test result data (instructor furnished); correctly classify soils of varying grain size, plasticity and compressibility using standard letter symbols in accordance with the unified soil classification system. The "plasticity chart" and the unified soil classification system "classification chart" may be used in determining the correct symbol along with instructor guidance. All student will be 100% accurate.

Topic 1.2.4 FIELD IDENTIFICATION OF SOILS Contact Hours: 7

Enabling Objectives: Upon completion of this topic, each student while working as a member of a team (not to exceed four (4) members) will be able to classify soils in the field and make a written report. The student will perform all seven (7) "Field Identification Tests", and the "Hasty Method of Testing", as outlined in this instructor guide and NAVFAC MO-330, Material Testing. This topic will be worked in conjunction with topic 1.2.2, Soil Exploration. Instructor guidance, class notes and student texts may be utilized in the performance of this topic's requirements. Each student's work will be 100 percent accurate for techniques and procedures employed with each test and as a class they should agree on all soil classifications with all differences being resolved after laboratory classification (topic 1.2.5) has been completed.

Topic 1.2.5 LABORATORY CLASSIFICATION OF SOILS Contact Hours: 12

Enabling Objectives: Upon completion of this topic each student will be able to classify the soil samples obtained as a result of the criterion test topic performance of 1.2.2, "Soils Exploration", using his own soils test results for (1) gradation percentage (2) grain size distribution curve and (3) plasticity and compressibility will be in accordance with the "Uniform Soils Classification System", as defined in the topic presentation and NAVFAC MO-330, Material Testing. Student work will be 100 percent accurate as checked, comparing his test results and the "Unified Soils Classification System", Table B-1, NAVFAC MO-330, Material Testing.

Topic 1.2.6 FIELD EVALUATION OF SOILS Contact Hours: 11

Enabling Objectives: Upon completion of this topic, each student while working as a member of a team (not to exceed (4) men) will be able to field evaluate soil for engineering purposes. The evaluation of soil in the field shall consist of two tests covered within this instructor's guide (in-place density and CBR field in-place test). Student procedures and techniques shall be 100 percent accurate and in accordance with those prescribed by this instructor's guide and NAVFAC MO-330, Materials Testing. Student test results should compare with all differences being discussed and resolved as a class.

Topic 1.2.3 SOILS CLASSIFICATION Contact Hours: 7

Enabling Objectives: Upon completion of this topic each student will be able to; given hypothetical test result data (instructor furnished); correctly classify soils of varying grain size, plasticity and compressibility using standard letter symbols in accordance with the unified soil classification system. The "plasticity chart" and the unified soil classification system "classification chart" may be used in determining the correct symbol along with instructor guidance. All student will be 100% accurate.

Topic 1.2.4 FIELD IDENTIFICATION OF SOILS Contact Hours: 7

Enabling Objectives: Upon completion of this topic, each student while working as a member of a team (not to exceed four (4) members) will be able to classify soils in the field and make a written report. The student will perform all seven (7) "Field Identification Tests", and the "Hasty Method of Testing", as outlined in this instructor guide and NAVFAC MO-330, Material Testing. This topic will be worked in conjunction with topic 1.2.2, Soil Exploration. Instructor guidance, class notes and student texts may be utilized in the performance of this topic's requirements. Each student's work will be 100 percent accurate for techniques and procedures employed with each test and as a class they should agree on all soil classifications with all differences being resolved after laboratory classification (topic 1.2.5) has been completed.

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ANNEX I

TEXTS

1. NAVFAC MO-330, Material Testing.

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ANNEX II

REFERENCES

1. ASTM (American Society for Testing Materials).
2. Lesson Reference File "Soil Exploration, U.S. Army Engineer School, S.002-518.
3. Soils Engineering, U.S. Army Engineer School, S.002-AO-SP-086.
4. Soil Cement Construction Handbook, Portland Cement Association.
5. Sample Technical Soils Report for use in SANLAC, S.002-556, FEB 1970, U.S. Army Engineer School.
6. TM-541, Control of Soils in Military Construction.

ANNEX III

TOOLS, EQUIPMENT AND MATERIALS

FSN/MFG NO.	ITEM	QTY	COST	EXT. COST
	Pencils, No.2	2 doz.	.35	.70
7530-285-3038	Paper, Note Pad	12 ea.	.42	5.04
Alvin 1010-13	French Curve	12 ea.	.48	5.76
Alvin PR 120T	Slide Rule	12 ea.	1.95	23.40
	Book, Material Testing	12 ea.	None	None
Soils Test Cat., LT-20	Cans, Moisture, 2" Dia. 1 1/4" High	3 doz.	2.50	7.50
MC-321	Tester, Speedy Moisture	4 ea.	258.00	1,032.00
MC-322	Reagent	4 pts.	.96	3.85
	Alcohol, Denatured	2 qts.	.50	1.00
L-817	Balance, Specific Gravity Determination, 31 gms. cap.	4 ea.	43.50	174.00
CL-315	Brush, Varnish, 1"	4 ea.	2.00	8.00
	Sieves, Test, 8" Dia. consisting of the following:			
CBC 8200	2", Full Height (2" deep)	4 ea.	14.95	59.80
CBC 8150	1 1/2", Full Height (2" deep)	4 ea.	14.95	59.80
CBC 8100	1" Full Height (2" deep)	4 ea.	14.95	59.80
CBC 8075	3/4" Full Height (2" deep)	4 ea.	14.95	59.80
CBC 8025	1/4" Full Height (2" deep)	4 ea.	14.95	59.80
CB 84	U.S. No. 4, Half Height (1" deep)	4 ea.	14.95	59.80
CB 810	U.S. No. 10, Half Height (1" deep)	4 ea.	13.75	55.00
CB 860	U.S. No. 60, Half Height (1" deep)	4 ea.	13.75	55.00

FSN/MFG NO.	ITEM	QTY	COST	EXT. COST
G-170	Thermometer	4 ea.	3.00	12.00
CL-250	Glass Plate, 6" x 6" x 1/2"	4 ea.	2.25	9.00
G-66	Cylinder, Graduated 100 Ml.	4 ea.	3.65	14.60
CN-405	Molds, Proctor w/base plate & collar	4 ea.	25.00	100.00
CN-416	Tamper, 10 lbs.	4 ea.	22.75	90.00
CN-838	Straight edge, Steel	4 ea.	3.00	12.00
LT-614	Pans, Mixing, 25 x 17 x 1	8 ea.	7.15	57.20
CN-995	Spoon, Cooking	4 ea.	1.35	5.40
CN-996	Can, Friction-top, 1 Gallon capacity	4 ea.	.80	3.20
CN-503	Hammer	4 ea.	6.50	26.00
5315-00-164-5121	Nails, 20d, Common	2 doz.	.50	1.00
CN-989	Tester, Soil Density, Sand Method Double Cone Assembly w/1 gal. jug.	4 ea.	16.00	64.00
CN-987	Tray, Template, Soil Density 4" hole	4 ea.	16.00	64.00
CL-316	Brush, Wire	4 ea.	1.50	6.00
CN-501	Ottawa Sand	100 lbs.	8.50	8.50
G-335	Pycnometer Jar w/cap & Gasket	4 ea.	3.50	14.00
	Oil, Lubricating	4 qts.	.60	2.40
CN-998	Chisel, 1"	4 ea.	2.75	11.00
L-3	Oven, Lab	4 ea.	67.50	270.00
LT-116	Asbestos Gloves	4 ea.	5.50	22.00

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FSN/MFG NO.	ITEM	QTY	COST	EXT COST
G-170	Thermometer	4 ea.	3.00	12.00
CL-250	Glass Plate, 6" x 6" x 1/2"	4 ea.	2.25	9.00
C-66	Cylinder, Graduated 100 Mi.	4 ea.	3.65	14.60
CN-405	Molds, Proctor w/base plate & collar	4 ea.	25.00	100.00
CN-416	Tamper, 10 lbs.	4 ea.	22.75	90.00
CN-838	Straight edge, Steel	4 ea.	3.00	12.00
LT-614	Pans, Mixing, 25 x 17 x 1	8 ea.	7.15	57.20
CN-995	Spoon, Cooking	4 ea.	1.35	5.40
CN-996	Can, Friction-top, 1 Gallon capacity	4 ea.	.80	3.20
CN-503	Hammer	4 ea.	6.50	26.00
5315-00-164-5121	Nails, 20d, Common	2 doz.	.50	1.00
CN-989	Tester, Soil Density, Sand Method Double Cone Assembly w/1 gal. jug.	4 ea.	16.00	64.00
CN-987	Tray, Template, Soil Density 4" hole	4 ea.	16.00	64.00
CL-316	Brush, Wire	4 ea.	1.50	6.00
CN-501	Ottawa Sand	100 lbs.	8.50	8.50
G-335	Pycnometer Jar w/cap & Gasket	4 ea.	3.50	14.00
	Oil, Lubricating	4 qts.	.60	2.40
CN-998	Chisel, 1"	4 ea.	2.75	11.00
L-3	Oven, Lab	4 ea.	67.50	270.00
LT-116	Asbestos Gloves	4 ea.	5.50	22.00

FSN/MFG NO.	ITEM	QTY	COST	EXT. COST
DR-10	Hand Augar 6" diameter bit	3 ea.	18.00	54.00
DR-36	6" diameter Augar bit	3 ea.	7.75	23.25
CN-973	Cone Penetrometer	3 ea.	210.00	630.00
LT-92ca	Sample bags	4 doz.	12.00	48.00
CN-1020	2" diameter Tube Sampler	3 ea.	60.00	180.00
CN-450	Mold CBR w/collar	45 ea.	35.00	1,575.00
LT-146	Bucket, 14 qt.	8 ea.	2.95	23.60
7330-634-4494	Bake Pan, 24" x 24"	3 ea.	13.10	39.30
CN-500	Paper filter	24 ea.	2.00	48.00
7330-00-153-9749	Rolling Pin Wood	3 ea.	3.86	11.58
CN-393	Spacer disc	45 ea.	11.00	495.00
CN-474	Frame CBR Loading	3 ea.	490.00	1,470.00
CN-400	Plate, Perforated w/adjustment Stem	3 ea.	13.00	39.00
CN-401	Tripod	3 ea.	15.50	46.50
LC-8	Dial Gauge 0.0001 inch accuracy	3 ea.	25.00	75.00
CN-557	Surcharge Weights, 5 lbs.	6 ea.	5.35	32.10
CN-472	Piston, Penetration, Steel, 1.954" dia. Jack, Screw Type, w/Handle and Proving Ring w/Micro Indicator, Dial w/Clamp, 0.001 inch accuracy	3 ea.	469.00	1,407.00
LT-475	Watch, Stop	3 ea.	40.00	120.00
	Spikes	1 bx.	8.70	8.70

ANNEX IV

TRAINING AIDS AND DEVICES

FILMS

1. SOI001 Soil- Cement Inspection and Field Control, 20 min.

LOCALLY PREPARED MATERIALS

1. Information Sheets.
    a. SCBT 440.2A EA IS 1.2.2.1, "Boring Log Sheet".
    b. SCBT 440.2A EA IS 1.2.3.1, "Unified Soils Classification System Chart".
    c. SCBT 440.2A EA IS 1.2.3.2, "Plasticity Chart".
    d. SCBT 440.2A EA IS 1.2.3.3, "Development of the Plasticity Chart".
    e. SCBT 440.2A EA IS 1.2.8.1, "Sample Soils Report".
2. Job Sheets.
    a. SCBT 440.2A EA JS 1.2.2.1/1.2.4.1, "Soil Exploration".
    b. SCBT 440.2A EA JS 1.2.3.1, "Soils Classification".
    c. SCBT 440.2A EA JS 1.2.9.1, "Stabilization Agents".
3. Sample Problem.
    a. SCBT 440.2A EA SP 1.2.3.1, "Soil Classification".
4. Practice Problem.
    a. SCBT 440.2A EA PP 1.2.7.1, "California Bearing Ratio.
5. Work Sheets.
    a. SCBT 440.2A EA WS 1.2.5.1, "Mechanical Analysis Data Sheet.
    b. SCBT 440.2A EA WS 1.2.5.2, "Mechanical Analysis".
    c. SCBT 440.2A EA WS 1.2.5.3, "Liquid and Plastic Limits".
    d. SCBT 440.2A EA WS 1.2.5.4, "Specific Gravity Determination".

e. SCBT 440.2A EA WS 1.2.5.5, "Soil Moisture Content".

f. SCBT 440.2A EA WS 1.2.5.6, "Compaction and Moisture Data Sheet".

g. SCBT 440.2A EA WS 1.2.5.7, "Compaction Test Data Sheet".

h. SCBT 440.2A EA WS 1.2.5.8, "Data Sheet - Soil Compaction Test Graph".

ANNEX V

TRAINING AIDS EQUIPMENT

1. 16mm movie projector.

ANNEX VI

MASTER SCHEDULE

FIRST WEEK

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
FIRST DAY				
1.1.1	C	1	Introduction and Safety	12/1
1.2.1	C	2	Introduction to Soils	12/1
		3		
1.2.2	C	4	Soils Exploration	12/1
		5		
	P	6		12/1
		7		
SECOND DAY				
1.2.2	P	8	Soils Exploration	12/1
		9		
1.2.3	C	10	Soils Classification	12/1
		11		
		12		
		13		
	P	14		12/1
THIRD DAY				
1.2.3	P	15	Soils Classification	12/1
		16		
1.2.4	C	17	Field Identification of Soils	12/1
		18		
	P	19		12/1
		20		
		21		
FOURTH DAY				
1.2.4	P	22	Field Identification of Soils	12/1
1.2.5	C	23	Laboratory Classification of Soils	12/1
		24		
	P	25		12/1
		26		
		27		
		28		

FIRST WEEK (Cont'd)

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
FIFTH DAY				
1.2.5	P	29	Laboratory Classification of Soils	12/1
		30		
		31		
		32		
SECOND WEEK				
FIRST DAY				
1.2.6	C	1	Field Evaluation of Soils	12/1
		2		
	P	3		
		4		
		5		
		6		
		7		
SECOND DAY				
1.2.6	P	8	Field Evaluation of Soils	12/1
		9		
		10		
1.2.7	C	11	Laboratory Evaluation of Soils	12/1
		12		
	P	13		12/1
		14		
THIRD DAY				
1.2.7	P	15	Laboratory Evaluation of Soils	12/1
		16		
		17		
		18		
		19		
		20		
		21		
FOURTH DAY				
1.2.7	P	22	Laboratory Evaluation of Soils	12/1
1.2.8	C	23	Soils Exploration Report	12/1
	P	24		12/1
		25		
		26		
		27		
1.2.9	C	28	Soils Stabilization Agents	12/1

SECOND WEEK (Cont'd)

TOPIC NO.	TYPE	PERIOD	TITLE	RATIO
FIFTH DAY				
1.2.9	C	29	Soils Stabilization Agents	12/1
	P	30 31		12/1
1.2.10	C	32	Soils Stabilization (Design Procedures and Control)	12/1

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
SPECIAL CONSTRUCTION BATTALION TRAINING (SCBT) 400-490

Classification: Unclassified

Topic: Introduction and Safety

Average Time: 1 Period (Class)

Instructional Materials:

A. Texts: None.

B. References:

1. NAVCONSTRACEN Instruction 5400.4 (Current Series), Organization Manual of NAVCONSTRACEN.

2. "Safety Practices for Shore Activities", NAVMAT P-5100, (Jan 73).

C. Tools, Equipment and Materials:

1. See Annex III of the Curriculum.

D. Training Aids and Devices: None.

E. Training Aids Equipment: None.

Terminal Objective: Upon completion of this unit the student will have registered for the course, received textbooks, complied with NAVCONSTRACEN and CBC regulations governing the reporting and fighting of fires which pertain to him as a SCBT student.

Enabling Objectives: Upon completion of this topic the student will be able to answer orally specific questions pertaining to the mission, regulations and organization of the command, and the method of reporting and fighting fires as established by NAVCONSTRACEN and CBC regulations. This topic is not meant to be disqualifying.

Criterion Test: The student will answer orally specific questions pertaining to the mission, regulations and organization of the command, and the method of reporting and fighting fires as established by NAVCONSTRACEN and CBC regulations.

Homework: None.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. INTRODUCTION TO THE LESSON	1. Introduce self and topic.	
A. Establish Contact.		
1. Name:		
2. Topic: Introduction and Safety		
B. Establish readiness	2. Motivate student.	
1. Purpose		
2. Assignment		
C. Establish Effect	3. Bring out need and value of material being presented.	
1. Value		
a. Pass course		
b. Perform better on the job.		
D. Overview:	4. State learning objectives:	
1. You will be able to answer orally specific questions related to the mission, regulations and organization of the Command, and the methods of reporting and fighting a fire as established by NAVCONSTRACEN and CBC regulations.	a. State information and materials necessary to guide student.	
2. Ask questions.		
3. Take notes		
4. Testable		

OUTLINE OF INSTRUCTION INSTRUCTOR ACTIVITY STUDENT ACTIVITY

11. PRESENTATION:

A. Introduction

1. Mission

a. Special training course

b. Higher state of readiness,

c. Compliance with COMCBPAC Instruction.

2. Organization and Chain of Command

a. Commanding Officer

b. Executive Officer

c. Training Officer

d. School Department Officer

e. Division Director

f. Senior Instructor

h. Class Petty Officer

3. Regulations and policies

a. Break procedures

b. Uniform regulations

(1) Working uniform of the day.

(a) Must be neat and clean.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

c. Absenteeism

- (1) Must be kept to a minimum.
- (2) Medical or dental sick call.
- (3) Permission to be absent.

d. Parking

- (1) Where
- (2) When
- (3) How

e. Visitors and phone calls

- (1) Emergencies only.
- (2) Phone numbers
    - (a) School number

f. Lost or damaged material

- (1) Text books
- (2) Publications
- (3) Tools
- (4) Materials
- (5) Statement of charges

g. Clean-up procedures

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY**

- h. Problems
  - (1) Scholastic
  - (2) Personal
  - (3) Counseling assistance
- 4. Standards of student performance
  - a. Written examinations
  - b. Homework assignments
  - c. Practical application
- 5. Course outline
  - a. Course mission
  - b. Course objectives
  - c. Reading assignments
  - d. Class schedule
- 6. Grading system
  - a. Homework
  - b. Practical application
  - c. Quizzes
  - d. Weekly tests
  - . Final examination

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
B. Safety		
1. Reporting accidents		
a. Class safety man	B.1.a. Pick safety man and explain job.	
b. Instructor		
c. School director		
d. First aid when appropriate.		
2. Fire safety		
a. Evacuation routes		
b. Reporting fires		
c. Fighting fires		
(1) Location of extinguishers.		
III. APPLICATION:		
A. Discussion	III.A. Questions To be developed by the instructor.	III.A Answers
IV. SUMMARY:		
A. Introduction		
1. Mission		
2. Organization and Chain of Command		
3. Regulations and Policies		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
4. Standards		
5. Course Outline		
6. Grading System		
B. Safety		
1. Reporting accidents		
2. Fire safety		
V. TEST:		
A. None		

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
SPECIAL CONSTRUCTION BATTALION TRAINING (SCBT) 440.2A

Classification: Unclassified

Topic: Introduction to Soils

Average Time: 2 Periods (Class)

Instructional Materials:

A. Texts:

1. NAVFAC MO-330, Materials Testing.

B. References:

1. Soils Engineering, Section I - Vol I Student Pamphlet, U.S. Army Engineer School, Fort Belvoir, Virginia, Stock number S.002-AO-SP-086.

C. Tools, Equipment and Materials:

1. See Annex III of the curriculum.

D. Training Aids and Devices: None.

E. Training Aids Equipment: None.

Terminal Objective: Upon completion of this unit each student will have explored, identified, classified and stabilized soils. Conditions, standards and procedures for each of the related topics leading to the successful completion of this terminal objective shall be as set forth in each topic.

Enabling Objectives: Upon completion of this topic each student will be able to define the "soil" and its origin based upon physical characteristics, particle size and location. Instructor guidance, class notes and student texts may be utilized in performing the requirements of this topic. All student responses will be written and 100% accurate after checking by the instructor. This topic is not meant to be restricting.

Criterion Test: Each student will make a written statement defining "soil" and its origin based upon physical characteristics, particle size and location. Instructor guidance, class notes and student texts may be utilized in performing the requirements of this topic. All student responses will be 100% accurate after checking by the instructor. This topic is not meant to be restrictive.

Homework: NAVFAC MO-330, Material Testing, chapter 1, para. 1-1 through 1-3 and chapter 2, para. 2-1 through 2-6.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Introduction to soils.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better quality control technician.		
D. Overview.	I.D. State learning objectives.	
1. You will be able to define soil within the guidelines of this lecture.	1. State information and materials necessary to guide student.	
2. Ask questions.		
3. Take notes.		
4. Testable.		

II. Presentation.

A. Introduction to soils.

1. What is soil?

a. As defined for construction: A heterogeneous accumulation of uncemented or loosely cemented mineral grains enclosing voids of varying sized. The voids may contain air, water, organic matter or any combination thereof.

2. Where does "soil" come from?

a. Breakdown of "parent material" (rock).

(1) Igneous rock.

(a) Cooled magma.

(b) Basalts & granites (examples).

(2) Sedimentary rock.

(a) Cemented pre-existing rock particles.

1. Clays & calcium carbonates are common cementing agents.

(b) Limestone, sandstone, shale (examples).

(3) Metamorphic rock.

(a) Heat & pressure.

1. Not enough to liquify, but still changes properties.

(b) Quartzite (metamorphosed sandstone), slate (metamorphosed shale), marble (metamorphosed limestone).

b. Mechanical weathering.

(1) Disintegration of rock without change of physical properties.

(a) Through freeze-thaw, landslide, etc.

c. Chemical weathering.

(1) Decomposition of rock with complete or partial change of chemical properties.

(a) Through acids, alkalies, gases, found in solution or atmosphere.

3. Soil categories.

a. Residual soil.

(1) Developed, by weathering, in-place from parent material.

(a) May have color change, but basically same as parent material.

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b. Transported soil.

(1) Alluvial soil.

(a) Water born and deposited when velocity is not sufficient to hold particles in suspension.

(b) River deposits at mouth forming deltas.

(2) Lacustrine soil.

(a) Fresh water lake deposits.

(b) Carried by rivers & streams but not to the ocean (as alluvials are).

(3) Marine soil.

(a) Formed & deposited by erosive action & tidal currents of the sea.

(4) Aeolian soil.

(a) Wind transported.

(b) Forms "dunes".

(5) Glacial soil.

(a) Carried with or pushed by glacial movement.

(b) "Till" - conclomerate of boulders, gravel, sand, etc. left after glacier melts.

(c) "Kame" terrace, "esker", outwash plain. - stratified deposits from glacier melt.

(6) Colluvial soil.

(a) Deposited by gravitational means (landslide).

1. If carried & re-deposited, they become alluvial.

4. Soils as related to construction.

a. All construction depends, entirely or to some great extent, upon its soil base.

(1) Will it bear structural load?

(a) Affects size & type of fastings.

(b) Determines if "select" fill is necessary.

(c) Piling, stabilization, etc. required.

(2) Will it stand up to wear?

(a) Determines if surfacing necessary.

(3) What are its drainage characteristics?

(a) Poor drainage affects stability.

b. Standard soils tests.

(1) Furnishes "common language" for engineers.

(2) Determines soil characteristics.

(a) Strength, drainage, etc.

(3) Basis for project design, specs & quality control.

5. Physical characteristics of soil.

a. Size.

(1) Determined by standard sieves:

Boulders - larger than 40".
Cobbles - 3" to 40".
Gravel - Passes 3", retained on #4.
Sand - Passes #4, retained on #200.
Fines - Pass #200.

b. Shape.

(1) Bulky.

(a) Angular (crushed run).

(b) Sub-angular.

(c) Sub-rounded.

1. Rounded (river run).

(c) Platy.

c. Gradation.

(1) Well graded.

(a) All sizes represented.

(b) Dense (has minimal voids).

1. Good bearing capacity.

2. Good drainage characteristics.

(2) Poorly graded.

(a) Narrow size range.

1. Uniformly graded.

(b) Lack of sizes.

1. Gap, step, or open graded.

6. Common soil tests.

II.A.6. Discuss topic 1.2.13, "Soils Exploration Report. Stress keeping all test work sheets, notes, etc.

a. Moisture content.

(1) Used, primarily, in conjunction with other tests.

b. Sieve analysis.

(1) For classification & gradation.

c. Specific gravity.

(1) Primarily for computations.

d. Atterberg limits.

(1) Classification.

e. Moisture - density (compaction).

(1) Density obtainable for a given soil.

f. Field density.

(1) Quality control.

III. Application.

A. Questions and discussion.

III.A. Questions.	III.A. Answers.
1. What are the three types of parent rock?	1. Igneous, sedimentary, metamorphic.
2. How is rock broken down?	2. Mechanical or chemical weathering.
3. A soil which is developed in place is called?	3. Residual soil.
4. Colluvial soil is deposited by what?	4. Gravitational means.
5. How is soil size determined?	5. Sieves.
6. What are the two shapes of soil?	6. Bulky or platy.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
B. Practical performance.	III.B. Read criterion test and explain to students. Have students make written statement.	III.B. Make written statement defining "soil".
1. Written definition of soil.		
IV. Summary.		
A. Introduction to soils.		
1. What is soils?		
2. Where does soil come from?		
3. Soil categories.		
4. Soils as related to construction.		
5. Physical characteristics of soil.		
6. Common tests.		
V. Test.		
A. See criterion test.		

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043

Classification: Unclassified

Topic: Soils Exploration

Average Time: 2 Periods (Class), 5 Periods (Pract)

Instructional Materials:

A. Texts:

1. NAVFAC MO-330, Material Testing

B. References:

1. TM5-541 - Control of Soils in Military Construction

2. Lesson Reference File "Soils Exploration", U.S. Army Engineer School. S.002-518

C. Tools, Equipment and Materials.

1. See Annex III

D. Training Aids and Devices:

1. Films - None

2. Transparencies - None

3. Charts - None

4. Locally Prepared Materials

   a. Information Sheet

Terminal Objective: Upon completion of this unit each student will have explored, identified, classified and stabilized soils. Conditions, standards and procedures for each of the related topics leading to the successful completion of this terminal objective shall be as set forth in each topic.

Enabling Objective: Upon completion of this topic each student while working as a member of a team (not to exceed four (4) members) will be able to gather information of engineering significance through soils exploration. This will be done by employing planning criteria, sampling methods and soil profile development outlined in this topic instructor guide and NAVFAC MO-330 Material testing. This topic will be worked in conjunction with topic 1.2.4, "Field Identification of Soils", Instructor guidance, class notes and student texts can be used in the performance of this topic requirements. Each students work will be 100 percent accurate for technique and procedures of soils exploration. As a class all exploration results should conform with differences being resolved through group discussions.

(1) SCBT 440.2A EA IS 1.2.2.1, "Boring Log Sheet".

b. Job Sheet

(1) SCBT 440.2A EA JS 1.2.2.1/ 1.2.4.1, "Soil Exploration".

E. Training Aids Equipment:

1. None

Criterion Test: Each student while working as a member of a team (not to exceed four (4) members) will be able to gather information of engineering significance through soils exploration. This will be done by employing planning criteria, sampling methods and soil profile development outlined in this topic instructor guide and NAVFAC MO-330, Material Testing. This topic will be worked in conjunction with topic 1.2.4, "Field Identification of Soils". Instructor guidance, class notes, and student texts can be used in the performance of this topics requirements. Each student will be 100 percent accurate for techniques and procedures of soils exploration. As a class all exploration results should conform with differences being resolved through group discussion.

Homework:

1. Read: NAVFAC MO-330. Material Testing, Chapter 2. Section II complete.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the Lesson		
A. Establish contact.	I.A. Introduce self and topic	
1. Name		
2. Topic: Soils Exploration		
B. Establish readiness	I.B. Motivate student.	
1. Purpose		
2. Assignment		
C. Establish effect	I.C. Bring out need and value of material being presented.	
1. Value		
a. Pass course		
b. Perform better on the job		
c. Get advanced		
d. Be a better Quality Control Technician		
D. Overview:	I.D. State learning objectives.	
1. You will be able to explore soils.	a. State information and materials necessary to guide student.	
2. Ask questions		
3. Take notes		
4. Testable		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

II. Presentation

A. Objective of Soil Exploration - is to gather as much information of engineering significance as possible pertaining to the subsurface conditions for a specific area.

1. Information determined.

a. Location, nature and classification of soil layers.

(1) Earthwork and foundation design can only be accomplished when the types and depths of soils to be encountered are known.

(2) Classification - A prediction as to the extent of problems concerning drainage, frost action, settlement and stability can be made.

(3) Samples for lab test should be taken even though field identification is used.

b. The condition of soils "In Place".

(1) Moisture content and density of a soil in its natural state sometimes plays an important part in design and construction.

c. Drainage characteristics

(1) Affect soil strength (Both surface and subsurface)

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(2) Controlling factors

(a) Void ration

(b) Soil structure and stratification

(c) Temperature of soil

(d) Depth of water table

(e) Height of capillary rise.

(f) Extent of local disturbances by roots and worms.

(3) Coarse grained soils best.

d. Ground water and bedrock

(1) All structures are constructed in such a manner as to be not adversely affected by the ground water table.

(2) Capillary water rise must also be considered.

(3) Bedrock can adversely affect construction if with-in the earthwork zone.

e. Develop a soil profile.

(1) The soil profile is a graphical representation of a vertical cross-section of the soil layers.

2. Sources of information

a. Several sources of information are used in soil exploration to help select the site or several areas for a construction site, but an/on site investigation must be made before final selection.

b. Published information

(1) Intelligence reports.

(a) Prepared by U.S. Army Engineers in conjunction with the U.S. Geological Survey.

(b) Include information relative to:

1 Geology

2 Topography

3 Terrain conditions

4 Climate and weather conditions

5 Sources of construction materials.

(c) Geologic Maps

1 Published in the folios of the U.S. Geological Survey for regions or quadrangles.

2 Formations are usually the smallest rock unit mapped.

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a Identified by letter symbols, color or symbolic patterns.

b Letters also indicate sand and gravel pits.

3 On rear of map a brief description of mineral resources, describing the location of construction materials.

(d) Topgraphic Maps

1. Best used in conjunction with Geologic Maps but can be used alone.

2. Contours can tell the following:

a Drainage patterns and slopes.

(1) Give clues to nature of rocks, weathering, soil and drainage.

(2) Examples:

(a) Sink holes may indicate limestone or glacial topography.

(b) Gently rounded slopes generally indicate deeply weathered rocks.

(c) Parallel ridges are commonly related to steeply folded bedded rock.

b Such features as: sand dunes, levees, beach ridges and alluvial fans can be recognized.

(e) Agricultural Soil Maps

1 General concerned with surface soil to 6 feet.

2 Factors found in:

- a Topography
- b Drainage
- c Vegetation
- d Temperature
- e Rainfall
- f Water sources
- g Rock locations

3 Soils are usually classified according to:

- a Texture
- b Color
- c Structure
- d Chemical composition
- e Physical composition
- f Morphology

(f) Air Photographs

1 Information that can be found and interperated from air photos.

a Land Form: Different types of deposits have definite land configuration and characteristics.

b Slope - Generally represents the texture of the soil.

(1) Granular - Steep

(2) Plastic Soils - flat

c Drainage patterns - Indicate pervious or impervious soil

(1) Also reflects underlying rock structure.

(a) Streams follow softer rock.

(g) Erosional Patterns -

1 The cross-section or shape of a gully is controlled primarily by the cohesiveness of the soil.

2 Each abrupt change in grade, direction, or cross-section is indicative of a change in the soil profile or rock layers.

a Short V-shaped gullies, steep gradients indicate cohesionless soils b U-shaped gullies indicate cohesive soils.

(h) Soil Color - Range from white to black on black and white photo.

1 Light colors or tones - pervious soils.

2 Light gray - sand

3 Dark gray to black - Clays or organic soils.

(i) Vegetation

1 Can indicate soil type if climate and other factors are known

(j) Land Use

1 Can indicate soil type.

c. Field Observations - Depend upon time available.

(1) Hasty field observations

(a) Features such as: Natural banks of streams, eroded area, road cuts and other exposed areas, the types of soil and depth of layers can be determined.

(b) Loose surface soil should be scraped off before observations.

(c) Samples can be taken for a field laboratory testing.

1. Usually kept to a minimum

(d) Soils should be located on a field sketch or on available maps or photographs.

(2) Deliberate field investigation - Two methods usually imployed. Also certain direct measurements can be made.

a. Test Pits

(1) Open excavation large enough for a man to enter.

(2) Best for studying natural soil conditions and collecting samples.

(3) Usually hand dug, can use power equipment such as dragline, clamshell, bulldozer, backhoe etc.

(4) Load bearing test can be performed.

b. Test holes - several methods

(1) Hand auger - most common

(a) Best for cohesive soils.

(b) Good up to 30 ft. in soft soil.

(c) Sample is disturbed but is satisfactory for determining:

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1. Soil profile

2. Classification

3. Moisture content

4. Compaction capabilites

5. Similar properties

(2) Wash Boring - Most common method used commercially for deep test holes except in rock.

(a) Good in all soils.

(b) Test hole made by chopping bit fastened to a wash pipe inside a steel casing (2,4,6 inches).

(c) Wash sampling is valueless for testing soils removed.

(3) Dry - Sample Boring - Same as Wash Boring.

(a) Uses a sample spoon to remove dry sample every time a new strata occurs or at specified depths.

(4) Undisturbed sampling -

(a) Used to obtain samples with negligible deformation for laboratory testing:

1. Shear strength

2. Compressibility

3. Permeability

(b) Equipment

1. Mohr Sampler

2. Thin-wall Sampler

3. Piston Sampler

4. Etc.

(5) Core Borings -

(a) Used to obtain samples from boulders, sound rock, frozen ground and resistant soils.

(6) Methods of Subsurface Exploration and Sampling.

(a) Penetrometers - used to determine the consistency of cohesive soils or the relative density.

1. Forced gently in to ground at a constant rate - cohesive soils.

2. Dynamic Penetration Test - Penetrometers driven into ground and number of blows per foot recorded--Cohesionless soils.

(b) Sounding Rods - Used to determine the depth to a hard layer.

1. Can be made from steel reinforcing bars or pipe.

(c) Vane Auger - Used to measure the shearing resistance of cohesive soils directly.

1. Consists of a rod with a four-bladed vane which is forced into the ground and then rotated. Force required to rotate it is used to determine shear.

2. Not good in sand or pebbles.

3. Types of soil samples.

a. Bag samples.

(1) Taken by the use of a shovel, pick, auger or other hand tool.

(2) Soil is disturbed

(3) Used for

(a) Mechanical analysis

(b) Plasticity

(c) Specific gravity

(d) Compaction and laboratory compacted CBR test.

b. Composite Samples

(1) A bag sample taken in order to obtain a representative mixture of all soil layers within a profile, stockpile or ETC to be investigated.

c. Moisture Content Samples

(1) Placed in sealed containers.

(2) 100 grams of soil is generally required. (Up to 1000 grams if gravel is contained).

d. Undisturbed Samples.

(1) Is one cut, removed and packed with the least amount of disturbance.

(2) Preservation of void ratio, moisture content and structure of soil is important.

(3) Used to determine:

(a) Unit weight

(b) Shear strength

(4) Types:

(a) Chunk samples cut with shovel and knife.

(b) Cylinder - obtained by forcing CBR mold or special sampler into ground.

(c) Box sample.

4. Locating, numbering and recording samples.

a. Log is kept for each test pit or hole.

(1) Depth of top and bottom of each soil layer (elevation).

(2) Field identification of each soil.

(3) Number and type of samples taken.

(4) Other information:

(a) Density.

(b) Changes in moisture content.

(c) Depth to ground water.

(d) Depth to rock.

b. Sketch of area or map with each test pit or hole accurately located on it by number.

5. The soil profile.

a. Development

(1) Consolidation of each of the logs.

(2) On cross-section paper.

(3) Shows - from surface downward.

(a) Soil depths.

(b) Water table.

(c) Moisture content of the various layers.

(d) Location of test holes or pits.

(e) Identification of each soil type.

(f) Finished grade line, and existing surface elevation.

(g) Details for plotting found in TM 5-541.

b. Use of the soil profile by the engineers during design and constuction is to try and forsee problems in:

(1) Drainage.

(2) Undesirable soils.

(3) Embankment work with soils.

(4) Location of grade line.

(5) Frost and capillary rise action.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
III. Application.		
A. Discussion.	III.A. Questions.	III.A. Answers.
	1. What affects does drainage characteristics have on a soil?	1. Affects soil strength.
	2. Name three (3) pieces of information determined by soil exploration.	2. a. Location, nature and classification of soil layers. b. In place soil conditions. c. Drainage characteristics.
	3. What is a soil profile?	3. A graphical representation of a vertical cross-section of the soil layers.
	4. Name the two types of field observation?	4. Hasty and deliberate.
	5. What material is a core boring used for?	5. Boulders, sound rock, frozen ground and resistant soils.

Procedures: Students will perform as many exploration borings as time permits dependent upon soil conditions for respective site selected. All soils will be classified, using the rapid method of "Field Identification", explained in topic 1.2.4. Each student will be provided the opportunity to use the penetrometers to establish the numerical index of the soil as well as its relative bearing value.

Upon completion of the field portion of the exercises, each group of students will prepare a complete log of each of the exploration boring including graphic representation, description and classification. The depth to ground water and pertinent remarks.

Using their own soil exploration data, each group of students will draw a soil profile of their portion of the training area. Instructor help will only be provided when asked for, or if difficulty is noted in individual cases. An understanding of techniques and equipment used is more important than test results obtained in these tests. Therefore, work assignments within each group will be rotated so that each man in the group gets the maximum experience in the time available.

Requirements:

1. In training area: Complete soil exploration field investigation.
    a. Complete digging of holes.
    b. Prepare samples for lab.
    c. Classify soil layers.
    d. Locate ground water table if possible.
    e. Use penetrometers.
    f. Clean equipment and fill up holes.
2. In classroom.
    a. Complete logging of holes.
    b. Complete soil profile.
    c. Boring log for each hole on SCBT 440.2A EA DS 1.2.4.1.

NAVAL CONSTRUCTION TRAINING CENTER
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SPECIAL CONSTRUCTION BATTALION TRAINING (SCBT) 440.2A

INFORMATION SHEET

REPORT OF FOUNDATION AND BORROW INVESTIGATION

SITE Airfield Jamock TYPE EXPLORATION Hasty DATE March 51

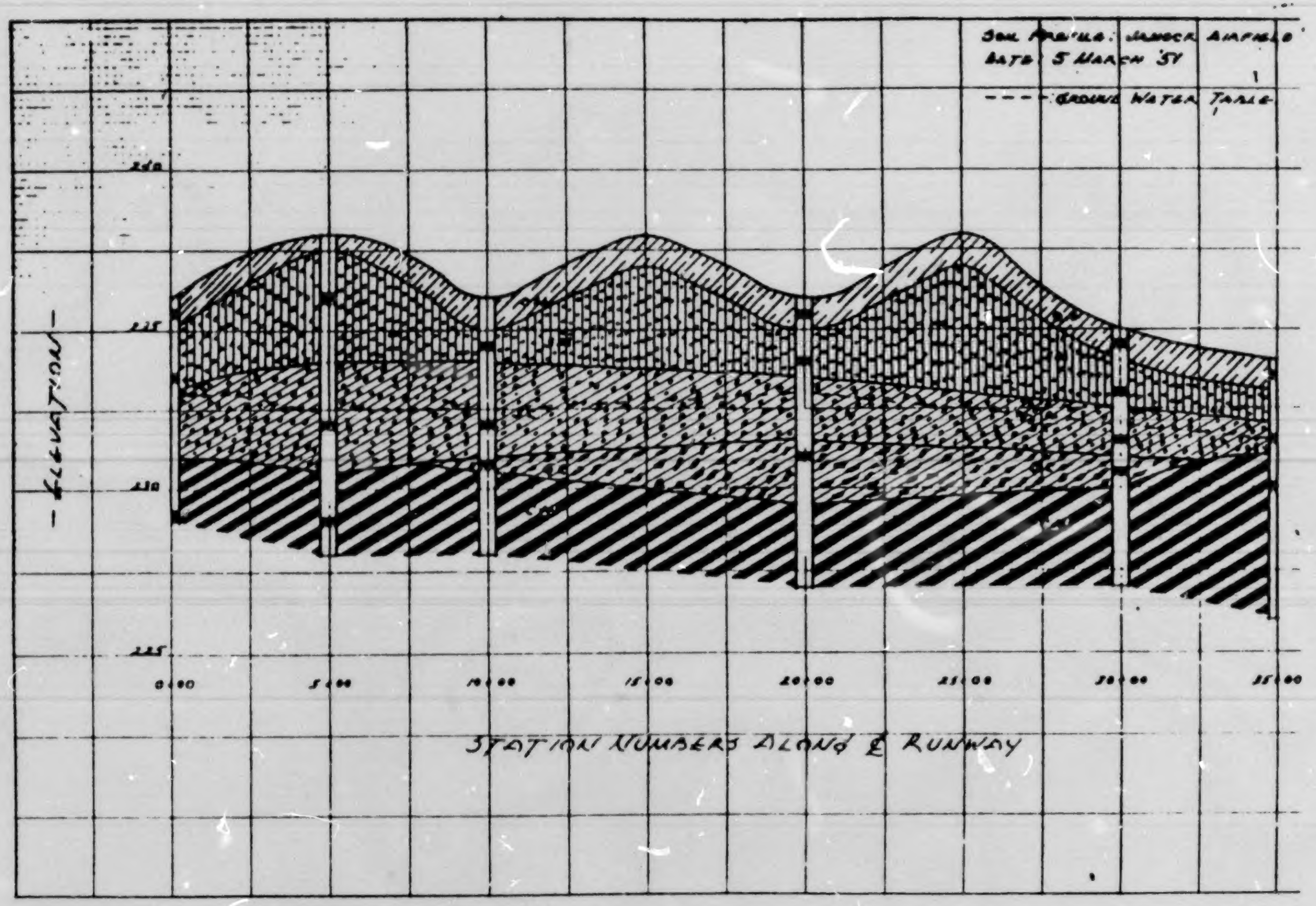
BORING NO. [illegible] LOCATION 20 + 00 GROUND ELEV. 236

PURPOSE OF EXPLORATION Determine soil profile along the centerline of runway.

DEPTH BELOW SURFACE Ft.	ELEV.	SAMPLE NO, TYPE & DEPTH	GRAPHIC LOG	GROUP SYMBOL	DESCRIPTION, TEST DATA, & REMARKS
1'	235	No. 10 at ½'	▨	OH	Brown and very plastic, Typical topsoil of the area.
2½'	233.5	No. 11 at 2'	▥	SM	Fine sandy soil with high percentage of silt. Light tan color.
4½'	231.5'		▨	SC	Coarse sandy soil with a plastic binder material. Light reddish color.
6½'	229.5'	No. 12 at 5'	▨	GC	Clayey gravel, high cohesion, sticky. Compact and very moist. Gravel heavily weathered and well rounded.
9'	227'		▨	CH	Brown, sticky clay with very high plastic qualities. Same material as found in boring No. 1 from 5 ft down.
					Bottom of hole.

DEPTH TO WATER TABLE 3 ft

SUBMITTED BY Col Mc Gurk


SOIL PROFILE: JANOCK AIRFIELD
DATE: 5 MARCH '54
---- GROUND WATER TABLE
240
235
230
225
- ELEVATION -
0+00
5+00
10+00
15+00
20+00
25+00
30+00
35+00
STATION NUMBERS ALONG ℄ RUNWAY

(2 of 2)

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SPECIAL CONSTRUCTION BATTALION TRAINING (SCBT) 440.2A

DATA SHEET

REPORT OF FOUNDATION AND BORROW INVESTIGATION

SITE ____________ TYPE EXPLORATION ____________ DATE ____________

BORING NO. ____________ LOCATION ____________ GROUND ELEV. ____________

PURPOSE OF EXPLORATION ____________

DEPTH BELOW SURFACE FT. ___	ELEV.	SAMPLE NO, TYPE & DEPTH	GRAPHIC LOG	GROUP SYMBOL	DESCRIPTION, TEST DATA, & REMARKS

DEPTH TO WATER TABLE ____________ SUBMITTED BY ____________

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
SPECIAL CONSTRUCTION BATTALION TRAINING (SCBT) 440.2A

Classification: Unclassified

Topic: Soils Classification (USCS)

Average Time: 4 Period (Class) 3 Period (Pract)

Instructional Materials:

A. Texts:

1. NAVFAC MO-330, Material Testing, 1971.

B. References:

1. American Society for Testing Materials Standards (ASTM)

2. Soils Engineering.

C. Tools, Equipment and Materials:

1. See Annex III.

D. Training Aids and Devices:

1. Films: None

2. Transparencies: None

3. Charts: None

Terminal Objective: Upon completion of this unit the student will have explored, identified, classified and stabilized soils. Conditions, standards and procedures for each of the related topics leading to the successful completion of this terminal objective shall be as set forth in each topic.

Enabling Objective: Upon completion of this topic each student will be able to; given hypothetical test result data (instructor furnished); correctly classify soils of varying grain size, plasticity and compressibility using standard letter symbols in accordance with the unified soil classification system. The "plasticity chart" and the unified soil classification system "classification chart" may be used in determining the correct symbol along with instructor guidance. All student work will be 100% accurate.

Criterion Test: Each student will correctly classify sixteen (16) different types of soils using instructor provided hypothetical test result data, "plasticity chart", and the unified soil classification system "classification chart". All student responses will utilize the standard letter symbols of the unified soil classification system. Students will be 100% accurate in all responses.

4. Locally Prepared Materials:

   a. Information Sheets.

      (1) SCBT 440.2A EA IS 1.2.3.1, Unified Soils Classification System Chart.

      (2) SCBT 440.2A EA IS 1.2.3.2, Plasticity Chart.

      (3) SCBT 440.2A EA IS 1.2.3.3, Development of the Plasticity Chart.

   b. Job Sheet.

      (1) SCBT 440.2A EA JS 1.2.3.1, "Soil Classification".

   c. Sample Problems.

      (1) SCBT 440.2A EA SP 1.2.3.1, Soil Classification.

E. Training Aids Equipment.

1. None

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the Lesson.	I. Introduce self and topic.	
A. Establish contact.		
1. Name.		
2. Topic: Soil Classification		
B. Establish readiness	I.B. Motivate student.	
1. Purpose		
2. Assignment		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Quality Control Technician.		
D. Overview:	I.D. State learning objectives.	
1. You will be able to classify soils using the unified soil classification system.	a. State information and materials necessary to guide student.	
2. Ask questions.		
3. Take Notes.		
4. Testable.		

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

II. Presentation

A. Soils Classification.

1. Unified soil classification system (USCS)

   a. Soils seldom exist in nature separately as sand, gravel, or any other single component. Because they are mixture we classify them so we can discuss their characteristics.

2. Basis of System.

   a. Three (3) general qualities of a soil

      (1) Percentages of gravel, sand and fines.

      (2) Shape of the grain size distribution curve.

      (3) Plasticity and compressibility characteristics.

   b. The system classifies soils into fifteen (15) groups based on physical properties.

      (1) Each group is represented by a two-letter symbols.

3. Letter Symbols.

   a. First letter describes the most predominant component by size in the sample. (Primary)

(1) That portion of the soil which has the greatest influence of the soils ability to support loads.

b. Second letter describes either (Secondary)

(1) The plasticity.

(2) The compressibility.

(3) Or the gradation.

(a) Whichever factor most completely describes the sample.

4. Letters Used.

a. Letters which can be used as the first (1st) letter is the two-letter symol can be:

(1) "G" for gravel and gravelly soils.

(2) "S" for sand and sandy soils.

(3) "M" for silt.

(4) "O" for organic silts and clays.

(5) "C" for clay.

(6) The symbol "M" to represent a silt was taken from the Swedish term "majala" (flour) used for fine-grained nonplastic or slightly plastic soils.

b. Letters which can be used as the second (2nd) letter (in addition to "C" and "M" which may also be used as a second letter to indicate the plasticity characteristics of a coarse grained soil):

(1) "W" for a well-graded soil.

(2) "P" for a poorly-graded soil.

(3) "L" for soils having low to medium compressibility.

(4) "H" for soils having high compressibility.

c. Highly organic soils, usually fibrous, such as peat and swamp soils having very high compressibility, are not subdivided and are placed in one group; symbol pt for peat.

5. Use of the system (Have student complete chart)

a. Divide soil into two (2) major divisions.

(1) Coarse grained soil.

(2) Fine grained soil.

b. A coarse grained soil is defined as one having less than 50% passing the #200 sieve, and is further divided into three (3) groups.

c. Group I

(1) Less than 5% of the sample passes the #200 sieve, and the minus #40 fraction is nonplastic (as determined by Atterberg Limits), the most important secondary characteristic, and therefore, the second letter will describe the samples gradation.

(2) Synbols GW, GP, SW, and SP refer to the groups that pertain to this catagory of the USC System.

(a) Gravel and sand mixtures contain little or no nonplastic fines.

(b) Presence of fines must not noticeably change the strength characteristics, and must not interfere with the free draining characteristics of the coarse grained fraction.

(c) Laboratory classification criteria has been established to judge if the soil is well-graded.

1. For GW, the co-efficient of uniformity (Cu) must be greater than (6).

2. For the SW, the Cu must be (4).

3. For both GW and SW the coefficient of gradation (Cg) must be between 1 and 3.

4. If above requirements are not satisfied the soil is poorly graded (GP or SPO).

d. Group II.

(1) When a coarse grained soil has less than 5% fines and the fines are plastic, or when the soil has between 5% and 12% fines, a "dual symbol" is used to describe the sample.

(2) The dual symbol identifies the most important grain size (sand or gravel), and also describes the gradation and secondary component.

(a) GW-GM describes a well-graded, silty grave.

(b) The remaining symbols in this group are:

1. GW-GC
2. GP-GM
3. GP-GC
4. SW-SM
5. SW-SC
6. SP-SM
7. SPO-SP

giving a total of eight (8) separate symbols under this group.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(c) Development of the Plasticity Chart.		
(1) For the determination of the predominant fine portion characteristic we rely upon the use of a chart devised by Dr. Casagrande, known as the Plasticity Chart. The "Plasticity index" is the ordinate and is plotted versus the "liquid limit" as the abscissa.		
(3) Development of Dr. Casagrande Chart.	d.(3) Pass out information sheet SCBT 440.2A EA IS 1.2.3.3, Development of the plasticity chart. Draw on chalkboard. Discuss with students.	d.(3) Follow chalkboar discussion of informati sheet.
e. Group III.		
(1) When a coarse grained soil has more than 12% fines, the plasticity of its fines defines the second letter of the symbol.		
(a) Plastic fines indicate clay ("C").		
(b) Non-plastic fines indicate silt ("M").		
(c) Exact determination made by plotting L.L. versus P.I. of the minus (-) #40 fraction as described.		

(2) Symbols in this group are:

- (a) GM
- (b) SM
- (c) GC
- (d) SC

(3) Special Case.

(a) A special case occurs when the L.L. is between 10 and 29 and the P.I. is more than 4 and less than 7. In this case a dual symbol is required to indicate that a borderline situation exists.

Example:

GC-GM identifies a gravelly soil with silty-clayey fines and with plasticity characteristics described.

Examples of other borderline soils:

A well-graded sandy soil with 10% passing the #200 sieve, with a L.L. of 32 and a P.I. of 10, would be designed as SW-SC. Should the soil have between 5% and 12% fines and the Atterburg Limits plot in the shaded portion of the plasticity chart, the secondary component could be clay or silt. The symbol representing the poorest of the possible groupings ("C" or "M") should generally be used. For example, as well-graded sandy soil

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
with 10% fines, LL of 27 and P.I. of 6 would be designed either SW-SC or SW-SM, depending upon the judgment of the senior EA.		
(4) Sample problem.	e.(4) Pass out sample problem SCBT 440.2A EA SP 1.2.3.1, Soils Classification, discuss with students.	e.(4) Classify soils.
(a) This is (f) of sample problem 4. Return to IG from here. The completed dual is a combination of these half symbols: "SW-SC". This soil is a well-graded clayey sand. 1. A soil that has 50% or more fines is called Fine-Grained and has the letter M (silt), C (clay), or O (organic) for the first letter. a. The second letter describes compressibility, H (high) or L (low). 2. Compressibility is the characteristic of a soil which causes it to change in volume under applied load. A soil that changes in volume significantly has high compressibility.		

a. By definition: FINE GRAINED SOILS WILL LL = 50% OR MORE ARE HIGHLY COMPRESSIBLE, AND GIVEN SECOND LETTER "H". LIQUID LIMIT OF LESS THAN 50% DEFINES A FINE-GRAINED SOIL WITH LOW COMPRESSIBILITY AND IS GIVEN A SYMBOL "L".

3. A soil which is predominately organic, whether it be a silt or a clay, will be given the symbol "O" as its first letter.

a. No boundry line divides organic from inorganic soils.

b. Organic soils are generally dark in color and have a musty odor. The odor can be detected in dry soil, but is much more noticeable in wet soil, or a heated sample.

c. Organic soils usually contain plant fibers.

d. Generally speaking, if a soil is dark colored, contains plant fibers, and has a musty odor it is considered an organic soil

4. In classifying inorganic, finegrained soil, the first letter in the symbol must be either an "M" or "C".

a. As in discussion of coarse-grained soils, division between silt and clay is made by using the plasticity chart.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
b. If LL and P.I. plot above A-line, first letter is "C", if they plot below A-line, first letter is "M".	5.b. Sketch of CB.	
5. On Plasticity Chart as LL of 50%, a heavy vertical line is drawn. This line is called the "B" line.		
a. Separate low and high compressible soils.		
b. Intersection of A and B lines on the chart divides it into four (4) distinct sections, representing the various groups of fine-grained soils.		
6. Final group is Pt.		
a. Given to generally dark colored, very highly organic soil (such as peat or swamp soil).		
b. Usually guite fibrous and is extremely compressible often having LL of 40 94 50.		
c. Easily recognized from visual examination, often so fibrous it cannot be sieved.		

7. Borderline Soils.

   a. Fine-grained soils with Atterburg Limits plotting in the shaded portions of chart are borderline cases which require a dual symbol of "CL-ML".

   b. No definite boundry between silt and clay exist here.

EXAMPLE:

An inorganic soil containing 25% gravel, 20% sand, and 55% fines, has a LL of 25 and a P.I. of 6.

This soil contains more than 50% fines, so it is fine-grained, The Atterburg Limits plot in shaded portion of chart so the soil is designated "CL-ML".

The judgment of the senior engineer is critical to the correct classification of the soil. The "CL-ML" symbol indicates a soil containing clay as well as silt properties.

If the project using this material was critical, the engineer could insure that proper care would be exercised in the use of this soil by designating it a "CL".

(b) Return to sample problem sheet SCBT 440.2A EA SP 1.2.3.1

B. Characteristics of Soil Groups Pertinent to Roads and Runways

1. General

a. Properties desired in soil for foundations under roads and air fields, and for base course under flexible pavements are:

(1) Adequate strength.

(2) Good compaction characteristics.

(3) Adequate drainage.

(4) Resistance to frost action.

(a) Areas where frost action is a factor.

(5) Acceptable compression and expansion characteristics.

b. Certain of these properties may be supplied by proper construction methods.

(1) Example: A material having good drainage characteristics is desired, but it is not available locally.

(2) Solution: Adequate drainage may be obtained by installing properly designed water collection system.

c. Strength requirements for base course materials to be used immediately under pavement are high.

(1) Only good-quality meterial are acceptable, however, low strengths in subgrade materials may be compensated for (in many cases) by increasing the thickness of overlaying concrete pavement, or of base materials in flexible pavement construction.

d. You can see that proper design of roads and air-field pavement requires evaluation of soil properties in more detail than is possible by use of the general soils classification systems.

(1) Grouping of soils in the classification system is such that a general indication of their behavior in road and airfield construction may be obtained.

2. Features shown on Soils Classification Sheet.

a. Column 1 - 5 show major soil divisions.

(1) Group symbols.

(2) Hatching.

(3) Color symbols.

b. Column 6 gives names of soil type.

c. Column 7 evaluates performance (strength) when used as subgrade materials not subjected to frost action.

d. Column 8 and 9 make similar evaluation for the soils when they are used as subbase and base materials.

e. Column 10 shows potential frost action.

f.. Column 11 shows compressibility and expansion characteristics.

g. Column 12 presents drainage characteristics.

h. Column 13 shows types of compaction equipment which performs satisfactorily.

i. Column 14 shows ranges for dry density for compacted soils.

j. Column 15, ranges of typical C.B.R. values to be anticipated for use in airfield design.

k. Column 16 gives ranges of modulus of subgrade reaction (K).

l. Note #3, letter symbols, basic soil groups, CM and SM, have each subdivided into two (2) groups designed "d" and "u".

(1) Chosen to represent desirable and undesirable base and subbase materials.

(2) Applies to roads and Airfields only, and is based on field observations and laboratory test.

(3) Basis for subdivision if the L.L. and P.I. on minus (-) #40 fraction.

(4) Suffix "d" = L.L. of 25 or less P.I. = 5 or less.

(5) Suffix "u" is used otherwise.

(6) Typical symbols for soils these groups are GMd and SMu.

m. The description in columns 7, 8, and 9 give a general indication of the suitability of the soil for use in subgrade, subbase, or base materials, when not subjected to frost action. Coarse-grained soil in general make the best subgrade, and base materials. The GW group has excellent qualities as a subgrade and subbase, and is good as a base material.

n. Regardless of the frost susceptibility (column 10) two conditions must be present simultaneously before frost action will be major consideration.

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(1) Source of water during freezing period.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
(2) Stratification of parent soil.		
(3) Transitions into cut sections.		
(4) Lateral flow of water from side cuts.		
(5) Localized pockets of perched ground water.		
(6) Drainage conditions.		
(a) In general, silts and fine silty sands are the worst offenders as far as frost is concerned.		
III. Application.	A.	
A. Discussion:	III.A. Questions	III.A. Answer.
1. To be developed by instructor.		
B. Practical performance.	III.B. Passout JobSheet SCBT 440.2A EA JS 1.2.3.1, Soils Classifications. Read Criterion Test and discuss both CT. and JS with students	III.B. Perform the requirements of the criterion test and sheet.
1. Classify soils.		
2. Solution for Job Sheet 1.2.3.1		
a. Problems.		

(1) 47% gravel, 28% sand when subtracted from the total 100% gives 25% fines. 25% fines places this soil in the range of more than 12% equal to or less than 50% of fines column on the Classification Procedure Chart. Percentage of gravel gives the first letter G. When plotting the LL of 40 and PI of 23 this falls above the "A" line in the clay range. Second letter is C. Final classification symbol = GC.

(2) 32% gravel 4% fines when subtracted from the total of 100% gives 64% sand. Since the 4% fines are non-plastic the soil will be placed in the less than 5% non-plastic fines column. The predominant percentage of sand fines the first letter S. With a C_c = 2.65 and C_u = 34.0, the sand classifies as well graded since the C_u is greater than 6 and the C_c falls between 1 and 3. Second letter is W. Final classification = SW.

(3) 18% gravel and 14% sand leaves a total of 68%. When plotting a LL of 35 and PI of 18 on the Plasticity Chart it falls above the "A" line in the clay range. First letter is C. With a LL less than 50 the clay is low compressible. Second letter is L, final classification symbol = CL.

(4) 54% gravel, 38% sand leaves a total of 8% fines. Soil falls in the range between 5% and equal to or less than 12% non-plastic fines column on the Classification Procedure Chart requiring a dual letter symbol. With 54% gravel the first and third letters are G. With a C_u of 15.0 and a C_c of 0.65, the criteria on Classification Chart for a well graded gravel has only been met by the C_u. Thus, the second letter is a P. Since the soil is non-plastic, the fourth letter is automatically an M. (Indicating silt fines). Final classification symbol = GP-GM.

(5) 24% sand when subtracted from the total 100% leaves 76% of fines. With a LL of 65, the soil falls into the equal to or greater than 50 LL column. When plotting the LL of 56 and PI 25 on the Plasticaity Chart this falls into the silt range. Hence, the first letter is M. Since the LL is greater than 50, the silt is highly compressable. Second letter H. Final classification symbol = MH.

(6) 63% gravel and 13% sand when subtracted from the 100% leaves a total of 24% fines. The soil falls on the Classification Procedure Chart into the more than 12%, equal to and less than 50% fines column. The 63% gravel gives the first letter of G. Since the soil is non-plastic, the second letter is automatically M. Final classification symbol = GM.

(7) 25% gravel and 37% sand leaves a total of 38% fines. The percentage of fines places the soil in the more than 12%, equal to and less than 50% column of the Classification Procedure Chart with 37% sand the first letter is an S. When plotting the LL of 45 and the PI of 9 on the Plasticity Chart it falls into the silt range. Since it is inorganic the second letter = M. Final clssification = SM.

(8) 0% gravel, 18% sand, and 82% fines. The soil is fine grained since is has more than 50% fines. With a LL of 80, it falls in the equal or greater than 50 LL column. Since the soil is organic, the first letter is O. With a LL of 80 the soil is highly compressible. The second letter is H. Final classification = OH.

(9) 9% gravel, 23% sand and 68% fines. The soil is again fine grained having more than 50% fines. The LL of 55 locates the soil on the Classification Procedure Chart in the equal to or greater than 50 LL column or high compressible. Plotting the LL of 55 and PI 32 it falls in the clay range. First letter = C. High compressibility gives a second letter of H. Final classification symbol = CH.

(10) 61% gravel, 35% sand and 4% fines. Since the gravel is predominant the first letter is a G. When plotting the LL and PI the fines fall in the clay range. This places the soil in the 0% equal to and less than 12% plastic fines column (dual letter symbol). Gradation characteristics is well graded, Cc = 1.80 Cu = 47. Second letter is W. Third letter is the same as the first, namely G. With 4% plastic fines the fourth letter is a C. Final classification symbol = GW-GC.

(11) 16% gravel, 9% sand and 75% fines. The LL of 85 places the soil in the equal to or greater than 50LL column. The LL of 85 and PI 40 classifies the soil as organic or silt but since it is nonorganic the first letter is a M. Since the LL is greater than 50 the second letter is H. Final classification symbol = MH.

(12) 39% gravel, 48% sand and 13% fines. The percentage of fines places the soil in the more than 12% equal to or less than 50% fines column. With 48% sand the first letter is S. Plotting the LL of 20 and PI of 3 the soil falls in the silt range on the Plasticity Chart. The second letter is M. Final classification symbol = SM.

(13) 15% gravel, 65% sand and 20% fines. The percentage of fines places the soil in the more than 12%, equal to or less than 50% fines column. With 65% sand the first letter is S. Plotting the LL of 50 and PI of 12, the soil falls in the silt range on the Plasticity Chart. The second letter is M. Final classification symbol = SM.

(14) 13% gravel, 21% sand and 66% fines. Since it has more than 50% fines the soil is fine grained. With a LL of 42 it falls in the less than 50LL column on the Classification Procedure Chart. Since it is an organic soil the first letter is O. With a LL of 42 it is low compressible. Second letter is L. Final classification = OL.

(15) 39% gravel, 29% sand and 32% fines. The soil falls in the range of more than 12% equal to or less than 50% fines column on the Classification Procedure Chart, with 39% gravel the first letter is G. Plotting the LL of 60 and PI of 42 the soil falls in the clay range on the Plasticity Chart. Second letter is C. Final classification symbol = GC.

(16) 11% gravel, 82% sand and 7% fines. With the high percentage of sand the first letter is S. The percentage of fines places the soil in the range between 5% equal to and less than 12% fines column on the Classification Procedure Chart. (dual letter symbol). Poorly graded since C_c is greater than 3. The second letter is P. Third letter is the same as the first. Since the soil is non-plastic the fourth letter is M. Final classification = SP-SM.

IV. Summary.

A. Soil Classification.

B. Characteristics of Soil Groups Pertinent to Roads and Runways.

V. Test: None.

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SAMPLE PROBLEMS

Title: Soil Classification Problems.

A. Sample Problems.

1. Sample Problem #1.

Given: From a sieve analysis a soil is found to contain 12% gravel, 88% sand, no fines. It has a Cu of 20 and a Cg of 1.3. It is not possible to obtain LL for the soil, and it is non-plastic.

Find: Symbol ____SW____

Solution:

a. Is soil coarse-grained or fine-grained?

(1) Soil is coarse if it has less than 50% fines.

(2) This soil has no fines, therefore it is coarse-grained with first letter of either "C" or "S".

(3) Soil contains 88% sand so first letter must be "S".

(4) Cu is 6 (greater than), and Cg is between 1 and 3. Thus, the soil is classified as an SW or a "well-grained sand".

2. Sample Problem #2.

Given: From the sieve analysis we find this soil contains 60% gravel, 36% sand, and 4% fines with the

Find: Classification symbol ____GP____

Solution:

a. The small amount of fines indicates a coarse-grained soil.

b. We have more gravel (60%), than sand (36%), so first letter is "G".

c. Soil contains less than 5% fines, so second letter is dependent upon gradation, "W" for well-graded, "P" for poorly-graded soil.

d. Sieve analysis shows the sand portion is limited to very fine sizes. Therefore, we have a gap-graded soil, so our second letter is "P".

e. The overall group symbol for this soil is "GP", or a "poorly graded gravel".

3. Sample Problem #3.

Given: A sieve analysis yields the following results, gravel 60%, sand 20%, and fines 20%. The plasticity test shows that the poriton of the soil passing the #40 sieve has LL-35 and P.O. 8.

Find: Classification symbol GM

Solution:

a. The soil has less than 50% fines, and the gravel portion is predominate so first letter is "G".

b. This soil contains more than 12% fines, and a LL was determined which means the soil has some plastic qualities.

c. Since the soil is plastic the second letter is based on the use of the plasticity chart. The second letter will be either "M" or "C".

d. Plotting LL = 35 and P.I. = 8 on the chart, we find the point falls below the A-line.

e. Thus, the overall group symbol is "CM", a "silty-gravel".

4. Sample problem #4.

Given: A sieve analysis yields the following results, 25% gravel, 70% sand, 5% fines, good gradation. Plasticity test determined LL = 25 and P.L. = 15.

Find: Classification symbol SW - SC

Solution:

a. This soil has less than 50% fines, and the sand portion is predominate, so first letter is "S".

b. The sample contains 5% fines, therefore, it requires a dual symbol to describe both its gradation and most important secondary component.

c. The first letter "S" will appear in each half.

d. Soil has good gradation, therefore the first half of the dual symbol is "SW".

e. The P.I. of any soil is equal to the L.L. - P.L. The P.I. of this soil = 25 - 15 or 10. Plotting the LL (25) versus the P.I. (10) on the plasticity chart, we find the most important second half of the dual symbol is "SC".

5. Sample problem #5.

Given: From the sieve analysis we find our soil contains 10% gravel, 15% sand, and 75% fines. From the plasticity test, we determined the portion passing the #40 sieve has an L.L. = 40, and a P.I. = 20. The soil gives no indication of being organic.

Find: Classification Symbol ____CL____

Solution:

a. Soil contains more than 50% fines, and is in-organic; therefore, the first letter is either "M" or "C".

b. When plotting L.L.versus P.I. we find our point falls above the A-line; therefore the first letter is "C".

c. The L.L. fall to the right of the B-line; therefore the second letter is "H".

d. The overall group symbol is "CH", or a "clay" with high compressibility.

6. Sample problem #6.

Given: Your soil technician leaves you with the following information:

a. All material passed the #40 sieve.

b. Sand = 10%.

c. L.L. = 60, P.I. = 20.

d. Organic soil.

Find: Classification Symbol ____OH____

Solution:

a. Since the soil has been deemed organic by the technician, the first letter is "O".

b. The L.L. is greater than 50, so the second letter must be "H".

c. Overall group symbol is then "OH" or a "highly compressible organic soil".

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JOB SHEET

Title: Soils Classification

Introduction: This job sheet is used to develop and measure your understanding of soils classification.

Situation: A soil technician has conducted a number of tests and he furnishes you with the following, incomplete information. What classification symbols should you assign to these two soils?

Required: Classify each soil using the unified soil classification system, and record the group symbol in the space provided.

Sample No.	Percentage - Dry Weight			LL	PI	Organic		Group Symbol
	Gravel	Sand	Fines			Yes	No	
1.	47.0	28.0		40	23		X	
2.	32.0 (Good representation of all particle sizes from 3/4" down) (C_c = 2.65, C_u = 34.0)		4.0	Non-Plastic			X	
3.	18.0	14.0		35	18		X	
4.	54.0 (Lacks material between 3/4" and No. 10 Sieve) (C_c = 0.65, C_u = 15.0)	38.0		Non-Plastic			X	
5.	0	24.0		65	26		X	
6.	63.0	13.0		Non-Plastic			X	
7.	25.0	37.0		45	9		X	
8.	0	18.0	82.0	80	30	X		
9.	9.0	23.0	68.0	55	32		X	
10.	61.0 (Good representation of all particle sizes from 3" down) (C_c = 1.80, C_u =47)	35.0	4.0	41	21		X	
11.	16.0	9.0	75.0	85	40		X	
12.	39.0	48.0	13.0	20	3		X	
13.	15.0	65.0	20.0	50	12		X	
14.	13.0	21.0	66.0	42	10	X		
15.	39.0	29.0	32.0	60	42		X	
16.	11.0 (74% of sample passes No. 4 sieve and is retained on No. 10 sieve) (C_c = 5.45 C_u - 17)	82.0	7.0	Non-Plastic			X	

(1 of 1)

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INFORMATION SHEET

Topic: Development of the Plasticity Chart.

(DEVELOP ON BB)

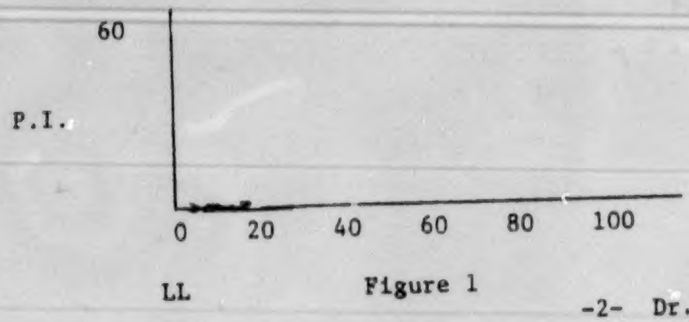

Figure 1

-2- Dr. Casagrande, who was searching for some easily measurable quantities which would distinguish clays and silts, plotted PI vs. LL for a large number of clays, with which he personally was familiar, on the Plasticity Chart. He found that almost all of these soils tested fell into one general range as illustrated.

(SKETCH ON BB)

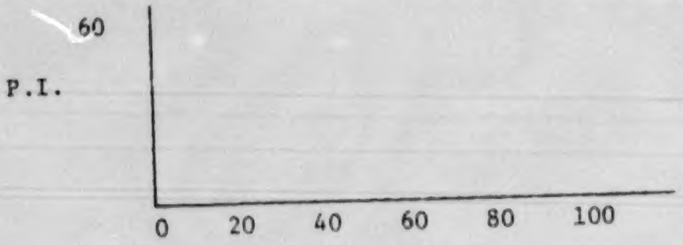

Figure 2

3. Similarly, he tested a large number of silts and organic soils (both plastic and non-plastic) and found that they, too, fell into another general range as illustrated.

(SKETCH ON BB)

CLAYS

P.I. SILTS

0 20 40 60 80 100

LL Figure 3.

4. Although these ranges overlap slightly, some clays falling into the general range of clays, a line was drawn on this chart as a boundry between clays and silts, based upon the above emperical boundry is in the form of a line on the plasticity chart called the "A" - line, and has an equation $Ip = 0.73\ (W1-20)$.

(SKETCH ON BB)

"A" LINE

CLAYS

60

P.I.

SILTS

0 20 40 60 80 100

LL Figure 4

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
SPECIAL CONSTRUCTION BATTALION TRAINING (SCBT) 440.2A

Classification: Unclassified

Topic: Field Identification of Soils.

Average Time: 2 Periods (Class), 5 Periods (Pract)

Instructional Materials:

A. Texts:

1. NAVFAC MO-330, Materials Testing.

B. References:

1- TM 5-541-Control of Soils in Military Construction.

C. Tools, Equipment and Materials.

1. See Annex III.

D. Training Aids and Devices:

1. Films: None

2. Transparencies: None

3. Charts: None

4. Locally Prepared Materials.

a. Job Sheet.

(1) SCBT 440.2A EA JS 1.2.2.1 and SCBT 440.2A EA JS 1.2.4.1, "Soil Exploration".

Terminal Objective: Upon completion of this unit, each student will have explored, identified, classified and stabilized soils. Conditions, standards and procedures for each of the related topics leading to the successful completion of this terminal objective shall be as set forth in each topic.

Enabling Objective: Upon completion of this topic, each student while working as a member of a team (not to exceed four (4) members) will be able to classify soils in the field and make a written report. The student perform all seven (7) "Field Identification Tests", and the "Hasty Method of Testing", as outlined in this instructors guide and NAVFAC MO-330, Material Testing. This topic will be worked in conjunction with topic 1.2.2, Soil Exploration. Instructor guidance class notes and student text may be utilized in the performance of this topics requirements. Each student will be 100 percent accurate for techniques and procedures employed with each test and as a class they should agree on all soil classifications with all differences being resolved after laboratory classification (topic 1.2.5) has been completed.

Criterion Test: Each student while working as a member of a team (not to exceed four (4) members will be able to classify soils in the field and make a written report. The student will perform all seven (7) "Field Identification Tests", and the "Hasty Method of Testing", as outlined in the instructors guide and NAVFAC MO-330, Materials Testing. This topic will be worked in conjunction with topic 1.2.2, Soil Exploration. Instructor guidance class notes and student text may be utilized in the performance of this topic requirements. Each students work will be 100 percent accurate for techniques

E. Training Aids Equipment:

1. None.

procedures employed with each test and as a class they should agree on all soil classifications with all differences being resolved after laboratory classificatio (topic 1.2.5) has been completed.

Homework: Read:

NAVFAV MO-330, Material Testing, Chapter 2, Section 1, Complete.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the Lesson.	I. Introduce self and topic.	
A. Establish contact.		
1. Name:		
2. Topic: Field Identification.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose		
2. Assignment		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Quality Control Technicia.		
D. Overview:	I.D. State learning objectives.	
1. You will be able to identify soils in the field during soils exploration as outlined in this topic and NAVFAC MO-330.	1. State information and materials necessary to guide student.	
2. Ask questions.		
3. Take notes.		
4. Testable.		

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

II. Presentation.

A. Introduction

1. Fundamental to soils evaluation.

2. Each test may be performed with a minimum of time and equipment.

3. Field identification is only an expedient and should not be used in lieu of labortory controlled test.

4. Soils properties which form the basis for the unified soil classification system are:

   a. Percentage of gravel sand and fines.

   b. Shape of the grain-size distribution curve (gradation).

   c. Plasticity.

   d. These properties are the primary considerations of field evaluation of soils.

5. Other characteristics observed should be included in describing the soil whether the identification is made by field or laboratory methods.

B. Field Identification Procedures.

1. Visual examination.

II.B.1 Demonstrate all procedures.

   a. Determines the color, grain size, and grain shape of the coarse-grained portion of a soil, and estimates the grain size distribution.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

b. Sample first dried and then spread on a flat surface.

(1) Color

(a) Distinguishing between various soil strata.

(b) Identifies local soil types.

(c) Condition of soil must always be recorded - color changes with moisture content.

(d) Dark or drab shades of gray or brown, almost all blacks indicate organic collodial matter fine grained soils (OL, OH).

(e) Clean and bright colors - medium and light grays, olive green, brown, red, yellow and white - indicate inorganic soils.

(f) Red, yellow, and yellowish brown can indicate iron oxides.

(g) White to pinkish - indicate considerable silica, calcium carbonate, or aluminum compounds.

(h) Grayish blue, and gray and yellow mottled - indicate poor drainage.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

(2) Grain size.

(a) Maximum particle size should be estimated.

(3) Approximate grain size distribution.

(a) By visual inspection.

(b) Spread on flat surface, then try and separate into various grain sizes.

(c) This will enable you to at least classify the sample as a coarse-grained or fine grained soil, 50% will pass No. 200 sieve.

(d) Coarse grain procedure.

1. First - less than 5% pass No. 200 sieve.

2. Second - fines are plastic.

3. If 1 and 2 are yes and all grain sizes represented, sample is well grade (GW or SW).

4. If grain size/sizes missing then sample is poorly graded (GP or SP).

5. When sieves are used in field (No. 4,40 and 200).

6. Washing - used to determine % of fines when No. 200 sieve is used and plasticity when No. 40 sieve is used.

7. A better approximation of the relative proportions of the components of the finer soil faction may sometimes be obtained by shaking a portion of the sample into a jar of water - settles into layers - gravel, sand and then silt and finally clays.

(4) Grain shape -

(a) By visual examination of gravel and sand grains individually.

(b) Effects soil stability round - friction and angular interlocking.

(5) Undisturbed soil properties should be described.

(a) Gravel and sand - "Loose, "Medium" and "Dense".

(b) Clay - "Hard", "Stiff", "Medium", "Soft".

(c) Based on several factors.

1. Difficulty of advancing the drilling or sampling tools.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

2. Consistency of the sample.

(d) In soft soils if the material is loose and compressible;as in an area under cultivation; spongy or elastic.

(e) Moisture content.

2. Breaking or dry strength test.

a. Performs only on the material passing the No. 40 sieve.

b. Used to measure the cohesive and plastic characteristics of the soil.

c. Test made of a part of soil 1/2 inch thick and about 1-1/2 inch in diameter.

(1) Mold soil into plastic state and into shape.

(2) Dry pat completely.

(3) After drying try and break between thumb and forefingers of both hands.

(4) After breaking try to powder it by rubbing it with the thumb and fingers of one hand.

(5) Example test results.

(a) Very highly plastic soils (CH) Very high dry strength , sample cannot be broken or powdered.

(b) Highly plastic soils (CH) high dry strength, can be broken with great effort, but cannot be powdered.

(c) Medium plastic soils (CL) medium dry strength - can be broken and powdered with some effort.

(d) Slightly plastic soils (ML, MH, or CL). Low dry strength - can be be broken quite easily and powdered readily.

(e) Non-plastic soils (ML or MH). Very little or no dry strength - crumbles and powders on being picked up.

(6) Caution - in clay soil pats, shrinkage cracks appear, breaks along these cracks are very misleading.

3. Roll or thread test.

a. Test is performed only on the material passing the No. 40 sieve.

b. Sample is prepared by adding water until the moisture content is such that the sample may be remolded without sticking to the fingers. (called the sticky limit).

c. Using a non-absorbent surface, such as glass or a sheet of heavy paper, the sample is rolled rather rapidly into a thread approximately 1/8 inch in diameter.

3.c. Demonstrate test.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

d. Plastic soils can be rolled, non/low plastic soils cannot.

(1) Degree of plasticity measured by its appearance after it has been remoulded into a ball.

e. Example test results.

(1) High plasticity (CH) - remolded into ball, deformed under extreme pressure.

(2) Medium plasticity (CL) remolded into ball, ball will crack and easily crumble under finger pressure.

(3) Low plasticity (CL, ML, or MH), cannot be remolded into a ball without completely breaking up.

(4) Organic materials (OL or OH) - forms soft spongy threads or balls when remolded.

(5) Non-plastic soils (ML or MH) - cannot be rolled into a thread at any moisture content.

4. Ribbon test.

4. Demonstrate test.

a. Test is performed only on material passing No. 40 sieve.

b. Moisture content below sticky limit.

c. Form a roll about 1/2 to 3/4 of an inch in diameter and about 3 to 5 inches thick.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

d. Place the roll in the palm of the hand and, starting with the one end squeezing it between thumb and forefinger, form a ribbon 1/8 to 1/4 inch thick.

(1) Handle with care.

e. If the sample holds together and forms a ribbon 8 to 10 inches long, soil is considered both highly plastic and compressive (CH).

f. If the soil cannot be ribboned it is non-plastic (ML or MH).

g. Ribboned with difficulty into short lengths - low plasticity (CL).

h. Roll and ribbon test complement each other.

5. Wet shaking test.

5. Demonstrate test.

a. Test is performed only on the material passing the No. 4 sieve.

b. Enough material to form a ball about 3/4 inch in diameter is moistened with water.

c. Just below the sticky limit but won't stick to fingers.

d. Place in palm of hand and shake vigorously.

(1) Usually done by jarring the hand on the table or some other firm object (other hand).

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

e. Soil gives a reaction to this test when water comes to the surface and produces a smooth shiny appearance (livery).

f. Then upon squeezing the sample between the thumb and forefinger of the other hand the surface water quickly disappears, surface becomes dull, material will resist deformation, and cracks will occur as pressure is continued, with the sample finally crumbling like a brittle material.

g. Example test results.

(1) Sudden or rapid - is typical of non-plastic, fine sand and silts (rock flour).

(2) Sluggish or slow - slightly plasticity - some organic or inorganic silts, or silts containing a small amount of clay.

(3) No reaction - typical of all inorganic clays and of the highly plastic organic clays.

6. Odor test.

a. Organic soils of the OL and OH groups usually have a distinctive, musty slightly offensive odor.

b. These are undesirable as foundation or base course materials.

7. Bite or grit test.

   a. A quick method of identifying sand, silt or clay.

   b. Small pinch is ground between teeth.

   c. Example test results.

      (1) Sandy soils - sharp hard particles - grate very harshly between teeth.

      (2) Silty soils - not nearly as harsh as sandy soils.

      (3) Clayey soils - not at all gritty - feel smooth and powdery like flour.

         (a) Will stick to tongue when lightly touched.

C. Hasty Method of Testing.

1. The hasty tests are used in conjunction with field identification test to classify soils.

2. A schematic diagram is provided in NAVFAC MO-330, Fig. 2.7 which may be used as a guide to the testing sequence in the process of assigning a symbol to a soil sample.

3. Tests.

   a. Sedimentation test.

      (1) By placing a small amount of soil (heaping tablespoon) into a transparent jar or container and adding about 5 inches of water and agitating by stirring or shaking. The

soil will be completely suspended in water.

(2) Settles out as follows:

2	seconds	- 0.4	Coarse sand - fine sand.
30	seconds	- 0.012	sand - fines.
10	minutes	- 0.08	coarse silt - fine silt.
1	hour	- 0.01	silt - clay.

(3) The most important use of this test is to differentiate the coarse fractions from the fine fractions of a soil.

(a) After 30 seconds, pour off remaining water and suspended material into another container (fines jar).

(b) Repeat test on remaining portion of original sample tested, and pour off water after 30 seconds.

(c) The results will give the amount of material passing the No. 200 sieve by evaporation or wicking off water in fines jar.

(4) Care in being sure all clay materials are suspended should be employed.

(a) Forms balls.

(b) Sand particles feel slippery when clay particles remain.

b. Cast test.

(1) Refers to the strength of a moist soil sample when squeezed in the hand.

(2) Used to indicate the approximate type and quanity of fines present in the sample.

(3) Water amount by trial and error.

(4) Test consists of:

(a) Compressing a handful of the moist soil into a ball or cigar-shaped cast and observing its ability to withstand handling without crumbling.

(b) Example test results.

1. GP, SP, SW, GW - cast crumbles when touched.

2. SM SC, - cast withstands careful handling.

3. ML, MH - cast can be handled freely.

4. CL, CH - cast withstands rough handling.

c. Wash, dust and smear test.

(1) Used to determine approximate silt contents of a soil.

(2) Tests consists of:

(a) Dust test - when completely dry sample of soil (with gravel portion removed) is dropped from a heighth of 1 or 2 feet onto a solid surface a silt content higher than 10% will produce a large dust cloud.

(b) Wash test - sample is placed in the palm of the hand and covered with about 1/8 inch of water. If water discolors and hides sample silt content higher than 5%.

(c) Smear test - sample (with gravel portion removed) is moistened to just below the "sticky limit" and then smeared between the thumb and forefinger. When it produces a gritty, harsh feel. This indicates a silt content of less than 10%.

III. Application

A. Application.

III. A. Questions	III.A. Answers
a. What type soil is usually identified by the odor test?	a. Organic.
b. The bite test is used to identify?	b. Sand, silt or clay.
c. In the wet shaking test rapid or sudden absorption of water indicates?	c. Non-plastic fine sands and silt.
d. A soil ribbon 8 to 10 inches long would indicate?	d. (CH) highly plas and compressive.
e. In the roll test a material which cannot be remolded into a ball without completely breaking up would be?	e. Of low plasticit (CL, ML or MH).

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
	f. In the breaking or dry strength test, the statement "crumble and powder on being picked up" indicates?	f. Non-plastic soils (ML or MH).
B. Practical performances. 1. Identify soils in the field in sonjunction with topic 1.2.2, Soils Exploration.	III.B. Pass out SCBT 440.2A EA JS 1.2.2.1/[illegible].2.4.1, Soil Exploration. Read the Criterion Test and explain both the job sheet and criterion test to the students.	III.B Perform the requirements of both the job sheet and the criterion test.
IV. Summary		
A. Introduction.		
B. Field Identification of Soil.		
C. Hasty Method of Testing.		
V. Test.		
A. None		

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
SPECIAL CONSTRUCTION BATTALION TRAINING (SCBT) 440.2A

Classification: Unclassified

Topic: Laboratory Classification of Soils

Average Time: 2 Periods (Class), 10 Periods (Pract)

Instructional Materials:

A. Text.

1. NAVFACT MO-330, Materials Testing

B. References:

1. None

C. Tools, Equipment and Materials:

1. See Annex III

D. Training Aids and Devices:

1. Films: None

2. Transparencies: None

3. Charts: None

4 Locally Prepared Materials:

a. Work Sheets.

Terminal Objective: Upon completion of this unit each student will have explored, identified, classified and stabilized soils. Conditions, standards and procedures for each of the related topics leading to the successful completion of this terminal objective shall be as set forth in each topic.

Enabling Objective: Upon completion of this topic each student will be able to classify the soil samples obtained as a result of the criterion test topic performance of 1.2.2, "Soils Exploration", using his own soils test results for (1) gradation percentage (2) grain size distribution curve and (3) plasticity and compressibility will be in accordance with the "Uniform Soils Classification System", as defined in the topic presentation and "Material Testing", NAVFAC MO-330. Student work will be 100 percent accurate as checked, composing his test results and the "Unified Soils Classification System", Table B-1 "Material Testing", NAVFAC MO-330.

Criterion Test: Each student will classify the soil sample obtained as a result of the criterion test performance of topic 1.2.2, "Soils Exploration", using his own test results for (1) gradation percentages, (2) grain size distribution curve, (3) plasticity and compressibility characteristics. The soil classification will be in accordance with the "Uniform Soils Classification System", as defined in this topic presentation and "Material Testing", NAVFAC MO-330. Student responses will

(1) SCBT 440.2A EA WS 1.2.5.1
Mechanical Analysis Data Sheet.

(2) SCBT 440.2A EA WS 1.2.5.2
Mechanical Analysis

(3) SCBT 440.2A EA WS 1.2.5.3
Liquid and Plastic Limits.

(4) SCBT 440.2a EA WS 1.2.5.4
Specific Gravity Determination

(5) SCBT 440.2A EA WS 1.2.5.5
Soil Moisture Content

(6) SCBT 440.2A EA WS 1.2.5.6
Compaction and Moisture Data Sheet

(7) SCBT 440.2A EA WS 1.2.5.7
Compaction Test Data Sheet

(8) SCBT 440.2A EA WS 1.2.5.8
Data Sheet - Soil Compaction Test
Graph.

E. Training Aids and Equipment:

1. None

be 100 percent accurate as checked, composing his test results and the unified soils classification system, Table B-1 "Material Testing", NAVFAC MO-330. The instructor should satisfy himself as to the predominant soil types in the area used for soils exploration and testing.

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the Lesson		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name		
2. Topic: Laboratory Classification of Soils.		
B. Establish Readiness.	I.B. Motivate student.	
1. Purpose		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Quality Control Technician.		
D. Overview:	I.D. State learning objectives.	
1. You will be able to classify soils using laboratory test data.	a. State information and materials necessary to guide student.	
2. Ask questions.		
3. Take notes.		
4. Testables.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation		
A. The following tests shall be conducted for laboratory classification of soils during this topic.	II.A. The information presented here is intended only as a review as all qualified students should be familiar with all tests with the possible except of the hydrometer analysis.	
B. Sieve Analysis.		
1. Purpose.		
a. Determine grain size distribution.		
(1) For gradation (well or poorly graded).		
(2) For classification (symbols SW, SP, GW, & GP).		
(3) Fineness modulus for concrete.		
(4) Aggregate blending needs.		
(a) Conc. & Bituminous mix designs.		
2. Procedures		
a. Obtain representative sample.		
(1) Size of sample depends upon maximum particle size.		

(a) Suggested sample sizes.

Maximum particle size	Weight sample (gms)
3"	6,000
2"	4,000
1"	2,000
1/2"	1,000
#4	500 - 750

b. Select proper sieve sizes.

(1) Depends on particular test and maximum particle size of sample.

(a) Mechanical anal: 3", 2", 1 1/2", 1", 3/4", 1/4", #4, #10, #40, #60, #100, #200.

(b) Fineness modulus: #4, 8, 16, 30, 50, 100.

(c) Other: refer to ASTM, or other manuals or as required for size separations.

(2) Clean each sieve (and pan).

(a) #30 and smaller w/bristle brush.

(b) 30 w/wire brush.

(3) Determine tare weight for each sieve and pan and record on form.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

c. Sample preparation.

(1) Oven dry and weigh sample.

(a) Record on form.

(2) Soak sample (24 hours - 2 hours min.).

(3) Wash sample through #200 sieve.

(a) Remove fines which would normally adhere to larger particles thereby giving erroneous test results.

(b) Use supplementry sieves to prevent soil build up on #200 sieve (#4, 40, etc.)

(c) Wash carefully until water is clear.

1. Reuse wash water.

2. Save all material and water unless - 200 material is not needed (for PL-LL,etc.)

(4) Oven-dry washed sample.

(5) Weight =200 material and record washing loss.

(a) Orig. wt. - washed wt. = washing loss.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

(6) Sieve sample through nest of sieves.

- (a) Some fines may still be in sample and will show up in pan.
- (b) Record weight of sieve and material retained on sieve.
- (c) Determine weight of material retained on each sieve.
  - 1. Plus any in pan.

d. Calculations.

(1) Determine total weight of fractions.

- (a) Wt. retained on each sieve + pan + washing loss = total wt. fraction.

(2) Calculate % error.

- (a) Orig. wt. - total wt. fractions = error in grams.
- (b) $\frac{\text{Error in grams}}{\text{original wt.}} \times 100 = \%\ \text{error}.$
  - 1. Greater than ± 1%, test must be re-run.

(3) Determine weight passing each sieve.

(a) Total wt. of fractions is first weight entered.

(b) Subtract progressively (cumulatively) each wt. retained from preceeding wt. passing.

(c) Wt. passing #200 should equal pan total.

1. Math check.

(4) Determine % passing each sieve.

(a) Wt. passing sieve / Total wt. fractions X 100 = % passing.

(b) % to one decimal place (slide rule accuracy.)

(5) Determine % gravel, sand, fines.

(a) Fines directly from form.

(b) Gravel = 100% - % passing #4.

(c) Sand = 100% - (% fines + % gravel).

C. Atterberg Limits.

1. Plastic limits test.

a. Obtain 250 - 300 gms. of #40 materials.

(1) Can use for LL test also.

OUTLINE OF INSTRUCTION INSTRUCTOR ACTIVITY STUDENT ACTIVITY

b. Place sample is evaporating dish and add water little at a time to approximate plastic limit.

(1) The point at which soil can be molded in a ball between palms of hands without sticking.

c. Mold a ball of soil 1/2" to 3/4" in diameter.

d. Place on clean glass plates and roll out with palm of hand to 1/8" thread.

(1) Use constant even pressure of hand.

(2) Roll at a rate of two, fore and back movements per seconds.

e. Plastic limit is the moisture content, to the nearest percent, at which the soil will roll out to a 1/8" thread without crumbling, but cannot be remolded and rolled out to a 1/8" thread again, without crumbling.

(1) If thread rolls out to less than 1/8", remold soil and work between fingers to evaporate moisture. DO NOT ADD DRY SOIL TO LESSEN MOISTURE CONTENT.

(2) If thread rolls out to 1/8" or less remold and roll out again. If crumbling occurs prior to 1/8", place thread in MC can, weigh, oven dry and determine MC. This is the plastic

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

NOTE: Do not "force" a PL by uneven rolling pressure of thread but, do not give up and report an NP soil after just a few attempts.

f. If soil will not roll out to 1/8" at any MC, report the soil as non-plastic (NP).

g. Two PL test with MC within 1% of each other is minimum requirement for valid test.

EXAMPLE: PL-1 has MC of 21.3%
PL-2 has MC of 21.9%
2 /43.2

Average: 21.6

PL: 22

2. Liquid limits test.

a. Liquid limits machine.

(1) Brass cup, hard rubber block, grooving tool.

(a) Drop of 1 cm. groove 1 cm, closure 1 cm.

b. Obtain approximately 200 gms of -#40 material.

(1) Or left over from PL test.

c. Calibrate LL Machine for 1 cm drop.

(1) Use grooving tool handle.

d. Mix soil with H^2O to consistency of skippy peanut butter, (Peter Pan too soft).

e. With spatula place soil in brass cup.

(1) Cover about half of the cup.

(2) Mold with spatula to even smooth depth of 1 cm.

f. Groove down center with grooving tool.

g. At a rate of 2 drops per second, turn handle, count number of blows it takes to close bottom of gap a distance of 1 cm.

h. Four runs at varying moisture contents is minimum.

(1) Two runs must obtain 1 cm closure between 15 and 25 blows.

(2) Two runs must obtain 1 cm closure between 25 and 35 blows.

i. If closure is not obtained within the limits, either add water or work soil with spatula to induce evaporation, whichever is applicable.

NOTE: If over 35 blows soil is too dry, add water, (very little). If less than 15 blows, soil is too wet, work with spatula. Never add dry soil!!

j. If closure is within limits, with spatula, remove soil across closure, weigh, oven dry, and determine moisture content.

k. Repeat process until four good runs are obtained.

    (1) Best to work from wet to dry soil.

l. Record all information on Atterberg Limits Data Sheet.

m. Plot on graph number of blows against MC for all four runs.

    (1) If perfect all points can be connected with a straight line having negative slope.

    (2) If one point far out - disregard.

    (3) Draw straight line as close as possible to points plotted.

n. Liquid limit is the moisture content at which the gap closes a distance of 1 cm with 25 blows of the cup at a rate of 2 blows per second.

o. On the chart go up the 25 blow line until intersection with plotted point line. Go over to MC. This is the liquid limit.

3. Plasticity Index (PI).

    a. LL - PL = PI.

    b. If soil is non-plastic, everything reported as NP.

c. Go to plasticity chart to classify.

(1) Plot LL against P.I. and read symbol from chart.

D. Specific Gravity

1. Testing procedures (coarse aggregate (+ #4)).

a. Apparatus

(1) Scale

(2) Dunagan apparatus or equivalent.

b. Sample

(1) 5 kg of + #4 material.

c. Procedure.

(1) Pre-wash sample to remove fines.

(2) Soak for 24 hours.

(3) Surface dry the sample.

(a) Wipe dry or roll in cloth.

(4) Obtain SSD weight of sample in air.

(a) Tare weight of container must be determined if used.

(5) Immediately determine weight of SSD samples in water.

(a) Tare weight must be offset on scale or its weight in water determined.

(6) Oven dry sample to constant weight of 110° C ± 5° and weigh.

d. Calculations.

NOTE: A temperature correction would normally be applied in the following formula if the water was not at 20° C. Since a variation of 10° C. only affects the results by one digit in the second decimal place (i.e. a.54 vice 2.55 with correction) and G is determined to two decimal places. The temperature correction may be dispensed with:

A - weight (gms) of oven dry sample in air.
B = weight (gms) of SSD sample in air.
C = weight of SSD sample in water.

$$G_b = \frac{A}{B-C}$$

NOTE: B-C determines the weight of an equal volume of water.

$$G_b \ (SSD) = \frac{B}{B-C}$$

$$G_a = \frac{A}{A-C}$$

$$\% \text{ Absorbtion} = \frac{B-A}{A} \times 100$$

which is nothing more then the Moisture content at SSD.

% absorbtion is used to adjust amount of water added to concrete mix if aggregate is not in SSD condition (i.e. more water needed if less than SSD and less if more than).

If two or more test run, results should check within:

Specific Gravity ---------- 0.02*
Absorbtion --------------- 0.05

* Another reason temperature correction dispensed with.

5. Testing Procedures (fine aggregate - #4).

a. Apparatus.

(1) Scale.

(2) Volumetric flask, 500ml, calibrated to ± 0.15 ml @ 20° C.

(3) Standard absorbtion cone and tamper.

(4) Water bath to maintain 68° F. (20° C.)

b. Sample.

(1) Approximately 1,000 gms. of # 4 material.

c. Procedure.

(1) Soak sample for 24 hours.

(2) Dry carefully to approximately SSD condition (no apparent "wetness".)

(3) Fill absorbtion cone with sample and tamp lightly 25 times.

(4) Remove cone.

(a) If free moisture present, sample will retain its shape.

(b) If SSD, sample will slump slightly and flake from sides.

NOTE: Always work from too wet down to SSD. To avoid accepting a slumped sample which is too dry.

(5) Immediately weigh out 500.0 grams of SSD material.

(6) Place in 500 ml flask and fill almost to 500 ml mark with water.

NOTE: weight of empty flask must be determined either before or after test.

(a) Roll flask or boil gently to remove all air bubbles.

(7) Place flask and sample in water bath at 20° C. for approximately 1 hour.

(8) Fill to 500 ml mark, remove and weigh flask, sample and water.

(9) Oven dry the sample to a constant weight at 110° C. ± 5° and weigh.

d. Calculations.

A = Weight (in gms) of oven dry sample in air.
V = Volume (ml) of flask.
W = Weight (in gms) of water added to flask.

$$G_b = \frac{A}{V-W}$$

NOTE: Since one ml of water = 1 gm of water, then V-W = wt. of an equal volume of water.

$$G_b \text{ (SSD)} = \frac{500.0}{V-W}$$

$$G_a = \frac{A}{(V-W) - (500-A)}$$

$$\% \text{ Absorbtion} = \frac{500-A}{C} \times 100$$ which is moisture content at SSD.

Check on 2 or more tests same as for course AGG.

E. Moisture Content.

1. Oven dry method.

a. Procedures.

(1) Clean, mark and weigh container.

(2) Weigh wet sample and tare.

(3) Place in oven and dry to constant weight at 110° C. ± 5°.

(a) 2 - 24 hours depending on soil.

(4) Remove from oven and weigh dry soil and tar.

(a) Allow to cool first.

(5) Determine weight of water.

(a) (wt. wet soil and Tare.) - (wt. dry soil and tare.)

(6) Determine weight of dry soil.

(a) (wt. dry soil and Tare) - (wt. tare).

(7) Calculate % moisture.

(8) This method is most accurate.

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY

F. Compaction

1. Procedures.

a. Obtain representative sample.

b. Quarter and seive air dried sample to size.

(1) Use - #4 material.

(2) Approximately 2500 gms air dried material per mold.

c. Clean and lightly oil mold, collar and tamper bottom.

d. Weigh and record mold without collar.

e. Weigh and record two moisture content cans per mold.

f. *Add water to material to obtain desired % moisture.

(1) If possible, let material stand overnight (covered with damp cloth) to allow thorough dispersal of moisture.

g. Compact each mold (with collar) as follows:

(1) Five equal layers.

(2) Twenty-five blows per layer with 10 lb., 18" drop, tamper.

(3) Scarify each preceeding layer.

(4) Last layer to extend slightly above top of mold after compaction.

h. Carefully remove collar and trim mold with steel straight edge.

i. Weigh full mold, without collar, and record.

j. Determine wet density.

(1) Weight of wet soil (lbs) X 30.

k. Obtain two representative moisture content samples per mold.

l. Determine moisture content.

(1) "Speedy" or "alcohol burn off" method may be used for rapid results, but two "oven dry" samples must also be determined.

m. Determine dry density.

(1) Dry density = wet density - 1 + moisture content expressed as a decimal.

n. Plot compaction curve.

(1) % moisture vs dry density.

(2) To be a valid curve, it must have two points above and two points below optimum moisture content.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
o. Determine OMC and 100% compaction.		
NOTE: Desired % moisture, based on a run of 5 or 6 molds, starts at approximately 6% and increases in increments of approximately 2%. This is based on an average soil usually having an OMC of between 9% and 12% and a valid compaction curve must have two points below and two points above OMC. The formula for amount of water to add to soil (in ml's) is:		
$\frac{\text{Wt. of wet soil in gms}}{1 + \text{moist. cont as a decimal}}$ X difference between existing and desired moisture contents expressed as decimal.		
III. Application		
A. Discussion	III.A. Questions	III.A. Answer-
1. To be developed by the individual instructors.		
B. Practical performance.	III.B. Read Criterion Test to students and explain, students perform required test and submit test data for evaluation.	III.B Perform required test.
1. Each student team will conduct the following test: (a) Sieve analysis. (b) Atterberg Limits. (c) Specific Gravity. (d) Moisture content. (e) Compaction.		

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

IV. Summary

A. Introduction.

B. Sieve Analysis.

C. Atterberg Limits.

D. Specific Gravity.

E. Moisture Content.

C

F. Compaction.

V. Test

A. None

SCBT 440.2A EA WS 1.2.5.1 122

MECHANICAL ANALYSIS DATA SHEET

PROJECT ____________________

SAMPLE NO. ____________ LOCATION ____________________

WT. ORIGINAL SAMPLE ________ C_u = ________ C_c = ________

WT. AFTER WASHING ________ CLASSIFICATION SYMBOL..... ________

WASHING LOSS ________ PER CENT ERROR............ ________

SIEVE SIZE	OPENING (mm)	WEIGHT OF SIEVE	WT. SIEVE & SAMPLE	WT. RETAINED ON SIEVE	WT. PASSING SIEVE	PERCENT PASSING	
2"	44.4						GRAVEL
1½"	38.1						
1"	25.4						
3/4"	19.1						
1/4"	6.35						SAND
NO. 4	4.75						
NO. 10	2.00						
NO. 40	0.42						
NO. 60	0.25						
NO. 100	0.149						
NO. 200	0.074						
PAN	☒						FINES

WASHING LOSS.............................. ________

TOTAL WEIGHT OF FRACTIONS.................. ________

PAN TOTAL (WASHING LOSS + PAN)................ ________

REMARKS

$$C_u = \frac{D_{60}}{D_{10}} \qquad C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

$$\text{PERCENT ERROR} = \frac{\text{ORIGINAL WEIGHT} - \text{TOTAL WEIGHT OF FRACTIONS}}{\text{ORIGINAL WEIGHT}} \times 100$$

SUBMITTED BY ____________ ORGANIZATION ____________ DATE ________

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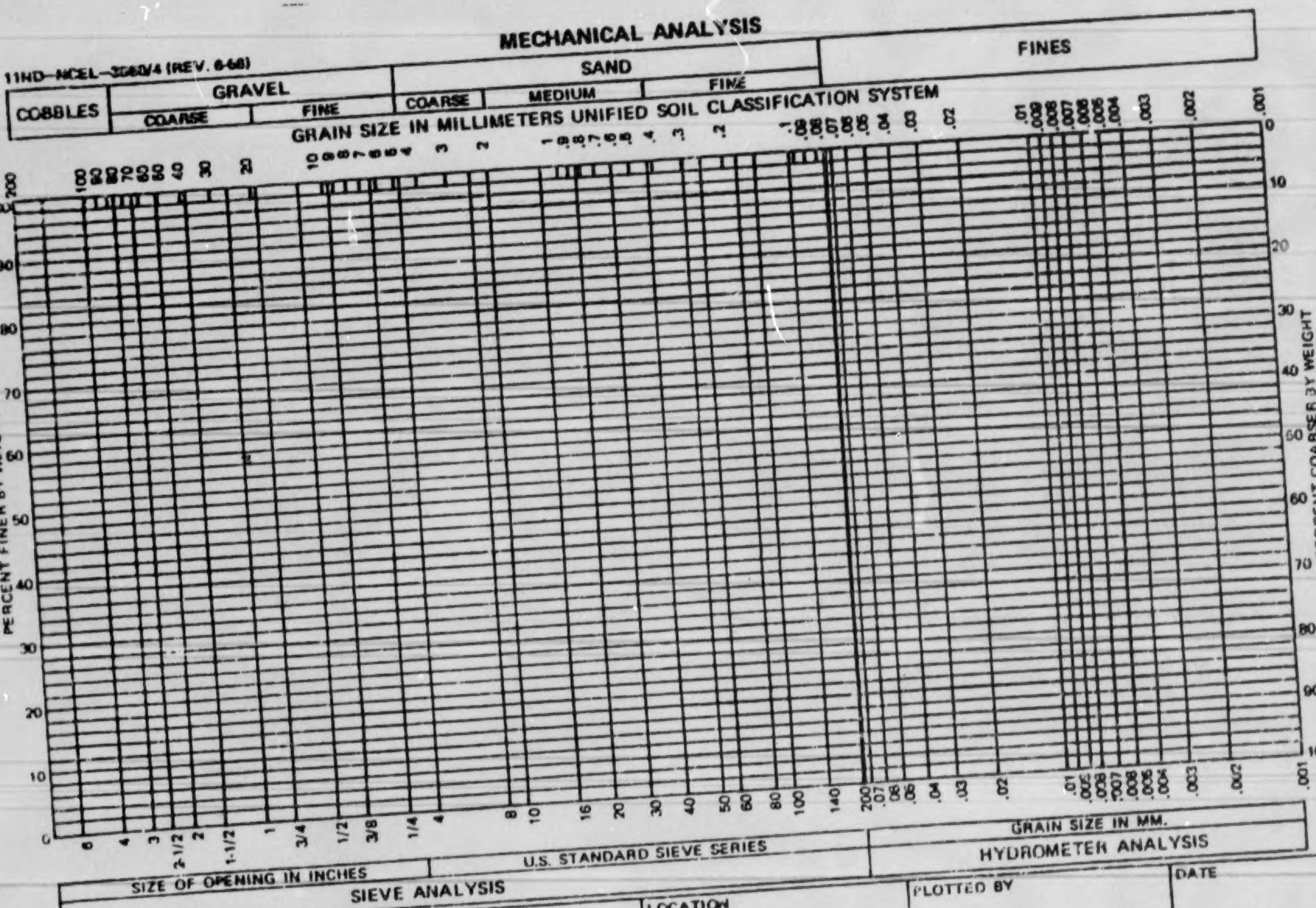

JOB

LOCATION

PLOTTED BY

DATE

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LIQUID and PLASTIC LIMITS

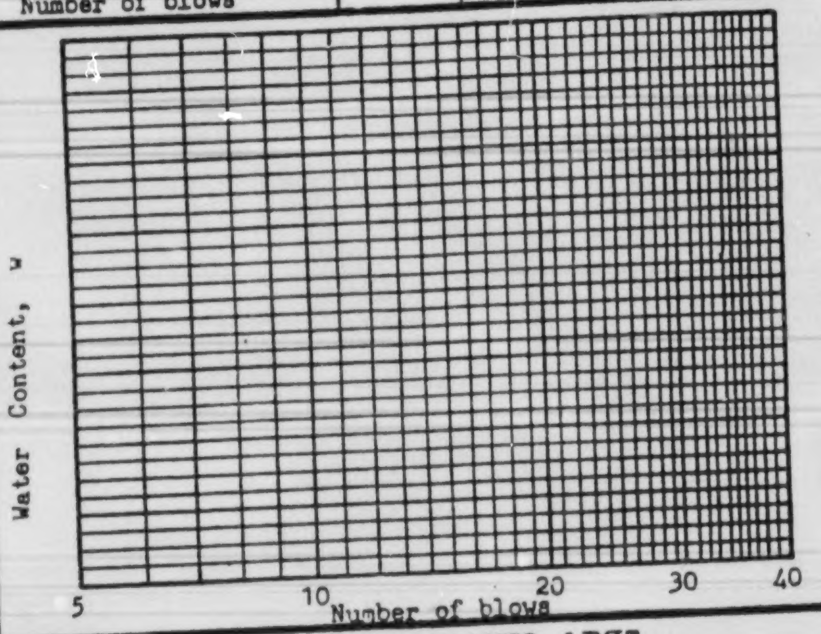
DATE ____________

PROJECT ____________ SAMPLE NO ____________

BORING NO ____________

LIQUID LIMIT

			1	2	3	4	5	6
RUN NO.								
TARE NO.								
Weight in grams	Tare plus wet soil							
	Tare plus dry soil							
	Water	W_w						
	Tare							
	Dry soil	W_s						
Water content		w						
Number of blows								



LL ____________

PL ____________

PI ____________

Symbol from plasticity chart

____

PLASTIC LIMIT

			1	2	3	4	5	Natural Water Content
Run No.								
Tare No.								
Weight in grams	Tare plus wet soil							
	Tare plus dry soil							
	Water	W_w						
	Tare							
	Dry soil	W_s						
Water content		w						
Plastic limit								

REMARKS ____________

TECHNICIAN ____________ COMPUTED BY ____________ CHECKED BY ____________

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SPECIFIC GRAVITY DETERMINATION
(PYCNOMETER METHOD)

PROJECT ______

SAMPLE NO. ______ LOCATION ______

DESCRIPTION OF SAMPLE ______

RUN NUMBER		
a. WEIGHT OF SAMPLE SSD		
b. WEIGHT OF SAMPLE OVEN DRY		
c. WEIGHT OF WATER (a-b)		
d. WEIGHT OF BOTTLE + WATER + SAMPLE		
e. WEIGHT OF BOTTLE + WATER ONLY		

TYPE SPECIFIC GRAVITY	FORMULA	CONDITION PLACED IN BOTTLE
BULK SSD (G_m)	$\frac{a}{(a+e)-d}$	SSD
BULK (G_b)	$\frac{b}{(a+e)-d}$	SSD
APPARENT (G_a)	$\frac{b}{(a+e-c)-d}$	SSD
BULK SSD (G_m)	$\frac{a}{(b+e+c)-d}$	OVEN DRY
BULK (G_b)	$\frac{b}{(b+e+c)-d}$	OVEN DRY
APPARENT	$\frac{b}{(b+e)-d}$	OVEN DRY

REMARKS

SPECIFIC GRAVITY = ______

PERCENT ABSORPTION

RUN NUMBER		
A. WEIGHT OF SSD SAMPLE + TARE		
B. WEIGHT OF OVEN DRY SAMPLE + TARE		
C. WEIGHT OF WATER		
D. WEIGHT OF TARE		
E. WEIGHT OF OVEN DRY SAMPLE		
PERCENT ABSORPTION ($\frac{C}{E}$ X 100)		

NOTE: 1 ml = 1 gm = 1 cc OF DISTILLED WATER AT 4° CENTIGRADE.

SUBMITTED BY ______ ORGANIZATION ______ DATE ______

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SOIL MOISTURE CONTENT

DATE

PROJECT

EXCAVATION NUMBER

SAMPLE NUMBER

FORMULA: Water Content, $w = \frac{W_w}{W_s} \times 100$

TEST						
RUN NUMBER						
TARE NUMBER						
A. WEIGHT OF TARE + WET SOIL						
B. WEIGHT OF TARE + DRY SOIL						
C. WEIGHT OF WATER, W_w (A. - B.)						
D. WEIGHT OF TARE						
E. WEIGHT OF DRY SOIL, W_s (B. - D.)						
WATER CONTENT, W	%	%	%	%	%	%
TEST						
RUN NUMBER						
TARE NUMBER						
A. WEIGHT OF TARE + WET SOIL						
B. WEIGHT OF TARE + DRY SOIL						
C. WEIGHT OF WATER, W_w (A. - B.)						
D. WEIGHT OF TARE						
E. WEIGHT OF DRY SOIL, W_s (B. - D.)						
WATER CONTENT, W	%	%	%	%	%	%
TEST						
RUN NUMBER						
TARE NUMBER						
A. WEIGHT OF TARE + WET SOIL						
B. WEIGHT OF TARE + DRY SOIL						
C. WEIGHT OF WATER, W_w (A. - B.)						
D. WEIGHT OF TARE						
E. WEIGHT OF DRY SOIL, W_s (B. - D.)						
WATER CONTENT, W	%	%	%	%	%	%
TEST						
RUN NUMBER						
TARE NUMBER						
A. WEIGHT OF TARE + WET SOIL						
B. WEIGHT OF TARE + DRY SOIL						
C. WEIGHT OF WATER, W_w (A. - B.)						
D. WEIGHT OF TARE						
E. WEIGHT OF DRY SOIL, W_s (B. - D.)						
WATER CONTENT, W	%	%	%	%	%	%
TEST						
RUN NUMBER						
TARE NUMBER						
A. WEIGHT OF TARE + WET SOIL						
B. WEIGHT OF TARE + DRY SOIL						
C. WEIGHT OF WATER, W_w (A. - B.)						
D. WEIGHT OF TARE						
E. WEIGHT OF DRY SOIL, W_s (B. - D.)						
WATER CONTENT, W	%	%	%	%	%	%

REMARKS *(Continue on reverse if additional space is required)*

TECHNICIAN *(Signature)*	COMPUTED BY *(Signature)*	CHECKED BY *(Signature)*

ENG FORM 1205

EDITION OF 1 AUG 57 IS OBSOLETE

GPO 883-974

DATA SHEET — COMPACTION & MOISTURE

Date________________

Project____ Sample No.__________

Report Submitted By____

Number of Layers-_______ Number of Blows per Layer_____ Weight of Tamper______ Height of Drop____

Test No.	Units						
Wt. of Sample + Mold							
Wt. of Mold							
Wt. of Wet Sample							
Wet Unit Wt.	lb/cu ft						
Can No.							
Wt. wet Sample + Can	gm						
Wt. Dry Sample + Can	gm						
Wt. Water	gm						
Wt. Can	gm						
Wt. of Dry Sample	gm						
Water Content	Percent						
Average Moisture Content	%						
Dry Unit Wt.	lb/cu ft						

(1 of 1)

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SCBT 440.2A FA W. L. .7

COMPACTION TEST DATA SHEET

METHOD: ________

PROJECT ________ WEIGHT OF TAMPER ________ HEIGHT OF DROP ________

NUMBER OF LAYERS ________ BLOWS PER LAYER ________ SPECIFIC GRAVITY ________

VOLUME OF MOLD ________ MAXIMUM PARTICLE SIZE ________

	UNITS						
RUN NUMBER							
WT. WET SOIL + MOLD							
WT. OF MOLD							
WT. OF WET SOIL							
WET UNIT WEIGHT (γ_w)	LBS/CU.FT.						

TARE NUMBER													
WT. WET SOIL + TARE													
WT. DRY SOIL + TARE													
WT. WATER (Ww)													
TARE WEIGHT													
WT. DRY SOIL (Ws)													

MOISTURE CONTENT (W)	PERCENT						
AVERAGE MOISTURE CONT.	PERCENT						
DRY UNIT WEIGHT (γ_d)	LBS/CU.FT.						

1 LB. = 453.6 gms.

$$W(\%) = \frac{W_w}{W_s} \times 100 \qquad \gamma_w = \frac{\text{WT. WET SOIL}}{\text{VOL. OF MOLD}} \qquad \gamma_d = \frac{\gamma_w}{1 + \frac{W}{100}}$$

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(1 of 1)

SOIL COMPACTION TEST GRAPH

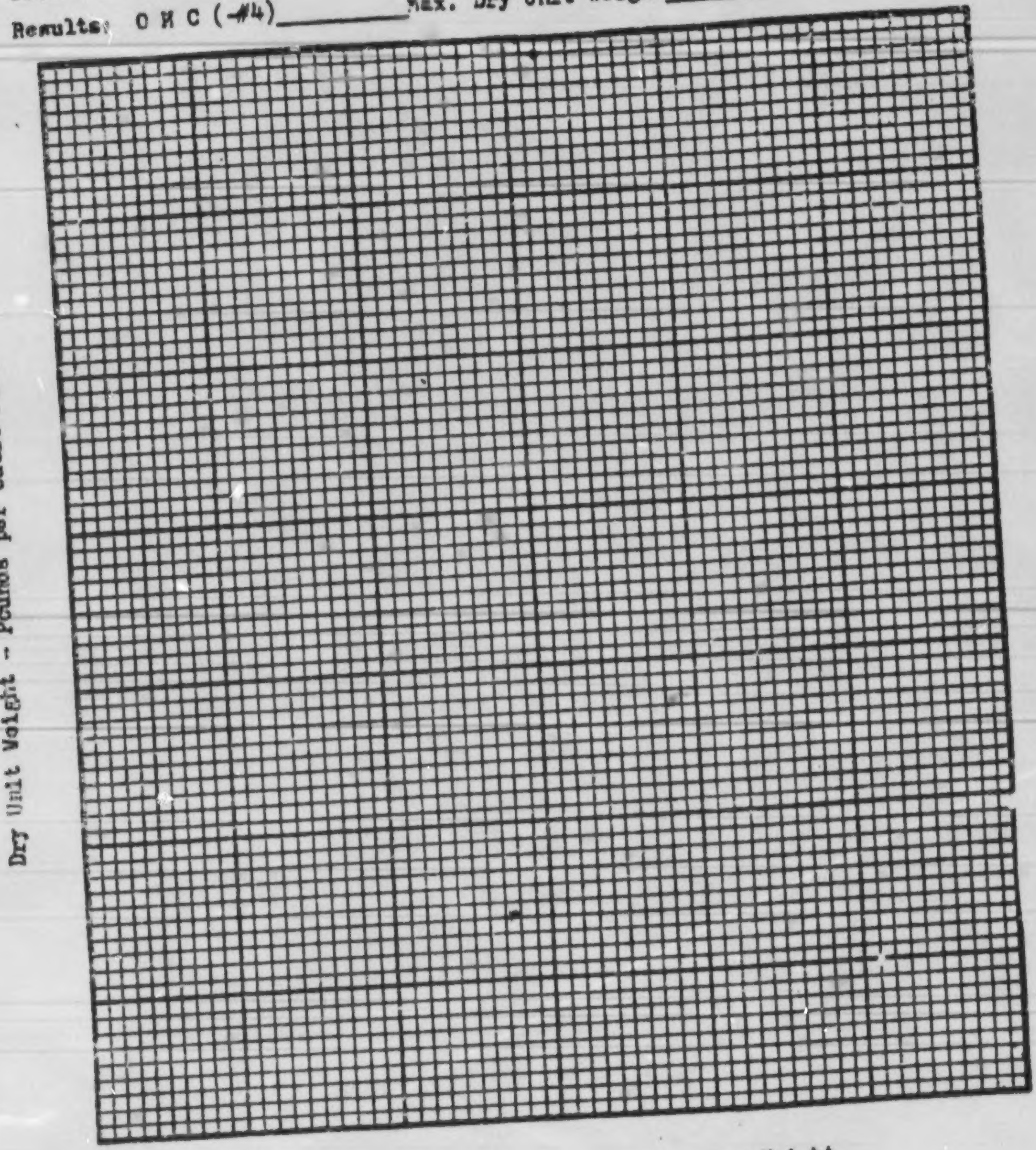
Date____________________

Project____

Report Submitted by__________________________Sample No.__________

Test Procedure____

Results: O M C (-#4)__________Max. Dry Unit Weight________________



(1 of 1)

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
SPECIAL CONSTRUCTION BATTALION TRAINING (SCBT) 440.2A

Classification: Unclassified

Topic: Field Evaluation of Soils.

Average Time:

Instructional Materials:

A. Texts:

1. NAVFAC MO-330, Material Testing.

B. References:

1. T5-541- Control of Soils in Military Construction.

C. Tools, Equipment and Materials.

1. See Annex III.

D. Training Aids and Devices:

1. Films: None

2. Transparencies: None

3. Charts: None.

4. Locally Prepared Material: None

Terminal Objective: Upon completion of this unit, each student will have explored, identified, classified and stabilized soils. Conditions, standards and procedures for each of the related topics leading to the successful completion of this terminal objective shall be as set forth in each topic.

Enabling Objective: Upon completion of this topic, each student while working as a member of a team (not to exceed four (4) men) will be able to field evaluate soil for engineering purposes. The evaluation of soil in the field shall consist of two tests covered within this instructors guide (in-place density, and CBR field in-place test). Student procedures and techniques shall be 100 percent accurate and in accordance with those prescribed by this instructor's guide and NAVFAC MO-330, Materials Testing. Student test results should compare with all differences being discussed and resolved as a class.

Criterion Test: Each student while working as a member of a team (not to exceed four (4) members) shall perform two tests involved in field evaluation of soil for Engineering purposes as-perscribed by this instructor's guide (in-place density, CBR field in-place test). Student procedures and techniques shall be 100 percent accurate and in accordance with those prescribed by this instructor's guide and NAVFAC MO-330, Material Testing. Student test results should compare with all differences being discussed and resolved as a class

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the Lesson		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name		
2. Topic: Field Evaluation of Soils.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Quality Control Technician.		
D. Overview:	I.D. State learning objectives:	
1. You will be able to evaluate soils in the field for load carrying capacity, density and strength.	a. State information and material necessary to guide student.	
2. Ask questions.		
3. Take notes.		
4. Testable.		

OUTLINE OF INSTRUCTION

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

II. Presentation

A. Field Density by the Sand Cone Method.

1. The sand displacement method of determining the in-place density may be used in either fine or coarse grained material.

2. Test so named because calibrated sand is used.

3. Test consists of:

a. Digging a hole with sample retained.

b. Determining the volume of the hole.

c. Determining the dry weight of sample.

-. Procedures.

a. Check tool list for completeness.

(1) NAVFAC MO-330 has listing.

(2) Calibrate sand.

(a) Use an attowa or rounded grain sand.

1. Passing #20 - retained on #40 sieve.

(b) Wash and dry.

1. Maintain dry sand always.

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

(c) Determine density of sand

1. Use Proctor Mold.

2. Exercise care.

3. Calculations.

a. Density $= \frac{\text{Wt.}}{\text{Vol.}} =$ lbs/cu ft.

4. Calabrate in lab.

(3) Surface preparation.

(a) Clean all loose material away.

1. Brush.

2. Use of knife, etc. disturb surface.

3. May use grader on areas, such as roads and air fields, with caution.

(b) Place plate

1. May require use of modeling clay.

(c) Place sand cone and calibrate surface.

1. Weigh bottle, sand and cone and record.

2. Release sand from bottle.

3. Remove sand cone.

4. Weigh and record remaining material.

OUTLINE OF INSTRUCTION

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

(d) Clean surface of sand.

(e) Dig hole.

1. Save all material.

2. Prevent H_2O evaporation.

3. Insure all loose material removed.

(f) Invert sand cone over hole and fill hole.

1. Weigh and record final weight.

2. Determine weight of sand in hole.

(g) Determine weight of soil from hole.

(h) Mix soil thoroughly.

(i) Secure sample for moisture content.

(j) Determine volume of hole.

1. Volume = $\frac{\text{Wt. sand in hole} \quad \text{lbs.}}{\text{Density of sand} \quad \text{CBS/c.f.}}$ = cu ft.

(k) w or wet density.

1. w = $\frac{\text{wt. of wet sample}}{\text{volume of hole}}$ = lbs/cu.ft.

(l) H_2O %

1. $w = \frac{\text{wt. of } H_2O}{\text{wt. of dry soil}} \times 100 = \%\ H_2O$

(m) d or dry density.

1. $d = \frac{w}{1 + \frac{w}{100}} = \text{lbs/cu.ft.}$

(n) Limitations.

1. Should not be used with heavy equipment moving close to test.

   a. Causes settlement of sand, giving high density readings.

B. CBR field in-place test.

1. The field in-place test is, under certain conditions, a satisfactory test for determining the load-carrying capacity of a material in-place in the field.

   a. Conditions.

      (1) When the in-place density and water content are such that the degree of saturation is 80 percent or greater.

      (2) When the material is coarse grained and cohesionless so that it is not greatly affected by changes in water content.

      (3) When the material has been in place for several years.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY.
b. Equipment. (1) Mechanical screw jack. (2) Calibrated proving rings. (3) Penetration piston (3 sq.in. end area, 6 in length) with internally threaded pipe extension with connectors. (4) Dial gages and support. (5) Circular steel plate. (a) 10 in. diameter. (b) 10 lbs. (c) 2-1/32 in. diameter hole in the center. (6) Surcharge weights. (7) Truck jacks. (8) Loaded trucks. (9) Beam kit.(Load, penetration and beam clamp). (10) Moisture content cans. (11) Carpenters level. (12) Plumb bob. (13) Stopwatch.	B.2.b. Demonstrate equipment and discuss.	

(14) Wrenches.

c. Preparations.

(1) Assemble on the rear bumper of loaded truck.

(2) Jack up truck, attach 6 in. I-beam to bumper and clamp for jack.

(3) Soil preparation.

(a) Level surface.

(b) Remove loose material.

(4) Seat and level initial 10 lb. surcharge weigh in a fine layer of Ottawa sand.

(a) Add additional 15 lb. surcharge weight for each 3 inches of overburden.

(5) Seat penetration piston at a 1 lb. load.

(6) Zero loading deflection gages.

d. Performance of test.

(1) Jack the penetration piston at a rate of 0.5 inch per minute.

(2) Obtain load reading at (inches deformation).

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

(a) 0.025
(b) 0.05
(c) 0.075
(d) 0.1
(e) 0.125
(f) 0.150
(g) 0.175
(h) 0.200
(i) 0.250
(j) 0.300
(k) 0.350
(l) 0.400
(m) 0.450
(n) 0.500

(3) Using the proving ring calibration determine the bearing value in pounds per square inch.

(4) Plot penetration versus load deformation (corrections if necessary).

(5) Compute corrected CBR in percentage.

d. (5) $\text{CBR} = \dfrac{\text{Test load in psi}}{\text{Standard load in psi}} \times 100\% =$
(0.1 inch = 1000 psi and 0.2 inch = 1500 psi standard load).

(6) Obtain soil sample at point of penetration for moisture content.

(7) Repeat procedures (1) through (6) above, two or more times in the same type soil.

(8) If results don't show reasonable agreement repeat test.

OUTLINE OF INSTRUCTION

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

(a)

CBR Range	Permissable tolerance
Less than 10	3
10 - 30	5
30 - 60	10
Above 60	Unimportant

e. The presentation of CBR data will be covered in topic 1.2.7, Lab evaluation of soils.

III. Presentation.

A. Discussion to be developed by the individual instructor respectively.

B. Practical perfromance.

1. Field evaluation of soils.

III.B. Read Criterion Test to students and explain. Have them conduct the field in-place density and CBR field in-place test.

III.B. Perform the field in-place density and CBR field in-place test.

IV. Summary

A. Field density by the sand cone method.

B. CBR field in-place test.

V. Test.

A. None

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
SPECIAL CONSTRUCTION BATTALION TRAINING (SCBT) 440.2A

Classification: Unclassified

Topic: Laboratory Evaluation of Soils.

Average Time: 2 Periods (Class), 9 Periods (Pract)

Instructional Materials:

A. Texts:

1. NAVFAC MO-330, Material Testing.

B. References:

1. Soils Engineering, Section I, Vol. I, U.S. Army Engineer School - S002-40-SP-086.

C. Tools, Equipment and Materials.

1. See Annex III.

D. Training Aids and Devices.

1. Films: None.

2. Transparencies: None

3. Charts: None

4. Locally Prepared Materials:

a. Practice problem.

(1) SCBT 440.2A EA PP 1.2.7.1. "California Bearing Ratio".

Terminal Objective: Upon completion of this unit, each student will have explored, identified, classified and stabilized soils. Conditions, standards and procedures for each of the related topics leading to the successful completion of this terminal objective shall be as set forth in each topic.

Enabling Objectives: Upon completion of this topic, each student while working as a member of a team (not to exceed four (4) members) will evaluate a soil sample under laboratory conditions using the principles and procedures of the California bearing ratio. All procedures shall be as outlined in the instructor's guide and NAVFAC MO-330, Material Testing. Each student will submit a report including the CBR family of curves. All student results shall be 100 % accurate for laboratory principles and procedures and laboratory results should compare.

Criterion Test: Each student while working as a member of a team (not to exceed four (4) members) will evaluate a soil sample under laboratory conditions using the principles and procedures of the California bearing ratio. All procedures shall be as outlined in this instructor's guide and NAVFAC MO-330, Materials Testing. Each student will submit a report including the CBR family of curves. All student results shall be 100% accurate for laboratory principles and procedures and laboratory results should compare.

Homework: Read: NAVFAC MO-330, Material Testing Section XII, para 2-T1 through para. 2 - 83.

E. Training Aids Equipment.

1. None.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name		
2. Topic: Laboratory Evaluation of Soils.		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Quality Control Technician.		
D. Overview.	I.D. State learning objectives.	
1. You will be able to evaluate a soil in the laboratory using CBR principles and test procedures.	a. State information and material necessary to guide student.	
2. Ask questions.		
3. Take notes.		
4. Testable.		

OUTLINE OF INSTRUCTION

INSTRUCTOR ACTIVITY

STUDENT ACTIVITY

II. Presentation.

A. Definition - The California Bearing ratio of soils is essentially a penetration test having the function of measuring the soil resistance to penetration prior to reaching its ultimate shearing value.

1. Defined as a percentage or ration from 0 to 100.

2. Based on a well graded limestone.

B. California Bearing Ratio test.

1. Minor variation in the CBR test procedures will cause wide variations in test results.

2. For materials containing gravel or stones, test has not been proven entirely satisfactory.

a. Remove in samples where it will not effect results.

3. A number of tests are run to assure a reasonable average value.

4. Most soils, test methods and results have proven satisfactory.

C. Equipment.

II.C. Illustrate equipment during lecture.

1. Mold, 6 inch diameter, 7 inch high, with detachable collar and with perforated base plate.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

a. Perforations maximum 1/16 in. diameter.

b. One extra base plate for use when mold is inverted.

2. Spacer Disk 5 - 15/16 inch diameter and 2 to 2.5 inches high.

3. Tamper, compaction-sliding weight type 10 lb.- 18 inch fall.

4. Adjustable stem and perforated plate, tripod and dialgage (reading to 0.0001 in.)

   a. Perforations not to exceed 1/16 inch.

5. Annular weight and several slotted weights. (516 EA)

6. Penetration piston having an end area of 3 square inches (1.95 inch diameter)

7. Laboratory testing machine, or screw jack and frame arrangement.

8. Miscellaneous equipment.

   a. Mixing bowls.

   b. Spatulas.

   c. Straightedges.

   d. Scales

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

e. Soaking tank or buckets.

f. Ovens.

g. Moisture contents.

h. Cants.

i. Etc.

D. Preparation of remolded samples.

1. Values obtained on test specimens which have the same density and moisture content expected in the field.

   a. Most critical - when maximum water has been absorbed.

   b. Usually run after sample has been immersed in water for a four (4) day period.

      (1) Contained in molds .

      (2) Confined with a surcharge equal to the weight of the planned base and pavement.

2. Size of material.

   a. Air-dried and mixed thoroughly.

   b. Broken up but not pulverized.

   c. Screened first over 3/4 inch sieve, then the #4 sieve.

(1) Remove all material retained on 3/4 inch sieve, replace with equal amount by weight of that passing 3/4 inch sieve and retained by the #4 sieve.

3. Compaction of sample.

a. The compactive effort used and the number of compacted samples required will depend upon the soil type weight and type of compactive equipment.

(1) Normally 12, 26, and 55 blows per layer (for five layers) are used in each of three (3) successive tests.

(a) Permits plotting the moisture, density and CBR relationship curves.

(2) Always use a 6 inch diameter mold with the 2 or 2 1/2 inch space disk.

(a) Hammer is always 10 lb. with 18 inch fall.

(3) All other procedures same as normal compaction control test.

4. Soaking the sample.

a. Place filter paper over trimmed end.

b. Remove perforated base plate and spacer block, place on trimmed end.

c. Invert mold - trimmed in becomes bottom.

d. Place the adjustable stem with the perforated plate on the top surface with a filter paper.

e. Apply surcharge weights.

  (1) Equal to expected load with in ± 5 pounds.

  (2) Never less than 10 lbs.

  (3) Record data.

f. Immerse in water-free access to top and bottom.

g. Using tripod and extensometer, obtain an initial reading for swell measurements.

  (1) Record data.

h. Normal required soaking period in 4 days.

  (1) Read at 1 day intervals.

i. After soaking read extensometer.

  (1) Amount of swell or consolidation is computed as a percent of initial height of specimen.

  (2) More than 3% is considered excessive.

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

5. Draining the sample.

    a. Remove free surface water.

    b. Allow specimen to drain downward for 15 minutes.

    c. Do not disturb surface of specimen.

    d. Remove perforated plate and surcharge weights.

    e. Weight specimen.

E. Penetration Test.

1. Surcharge.

    a. Use a surcharge equal to that used during soaking.

    b. If sample has not been soaked, surcharge should not be less than 10 lbs. but within ± 5 lbs. of base and pavement loads.

    c. To prevent soil from getting into the hole in the surcharge weight one 5 lb. annular disk should be inserted prior to seating the piston and final application of weights.

2. Seating piston.

    a. With a 1 lb. load.

    b. Set gages (stress and strain) at zero.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
3. Application of load.	E.3. Refer to MO-330. page 2-88.	
a. Approximately 0.05 inch per minute.		
b. Obtain readings at 0.025, 0.05,0.075, 0.1, 0.125, 0.150,0.175,0.20, 0.250, 0.300, 0.350, 0.400, 0.450, and 0.500 inch diameter of deformation.		
c. In manually loaded devices readings may be required more often.		
4. Moisture.		
a. Average moisture for the entire depth of sample.		
5. Stress - Penetration Curve	E.5. Refer to MO-330, page 2-89, discuss sample.	
a. The penetration load in pounds per square inch, is computed.		
b. Draw stress - penetration cure.		
6. California Bearing Ratio		
a. Determine the corrected load values in psi at 0.1 and 0.2 inches of penetrations. Computation - $\frac{\text{Loads ar 0.1 or 0.2}}{\text{Standard 1000 Or 1500 respectively}} \times 100 = \%/$		
b. Results at 0.1 are usually used for CRR.		
c. If results at 0.2 inch are larger, test showld be rerun.		

(1) If check test same, use 0.2 lb.

7. Test results should contain.

   a. Compaction procedures (modified AASHO)

   b. Compaction effort (12, 26 and 55 blows/layer).

   c. Molding water content (prior to soaking).

   d. Density (prior to soaking).

   e. Soaking and penetration surcharge.

   f. Expansion of sample (% swell).

   g. Moisture content after soaking (saturated condition).

   h. Density after soaking (saturated condition).

   i. Optimum moisture content and maximum dry density by modified AASHO.

   j. Plot and correction of stress - penetration curve if necessary.

   h. Calculate and select CBR value.

F. Test procedures for remolded samples.

1. Three groups foe CBR design methods.

   a. Cohesionless sands and gravels. (GW, GP, SW, and SP class).

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

b. Cohesive soils (GW, GC, SM, SC, ML, CL, and OL class.)

c. Highly swelling soils.(MH, CH, and OH class).

2. Procedures for each group.

a. Cohesionless sands and gravel.

(1) Usually compacts well.

(2) If soaking does not lower CBR, further test can be omitted.

b. Cohesive soils.

(1) Test over wide range of conditions.

(2) Compaction curves for 55, 26, and 12 blows/layer.

(3) Each specimen is soaked.

(4) Penetration tested.

(5) Family of curves drawn for showing the relationship between density, molding, water content and corrected CBR.

c. Swelling soils.

(1) Procedures same as cohesive soils.

(2) Test is used to determine a moisture content and a unit weight which will minimize expansion.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
G. Example Problem:	G. Pass out practice problem SCBT 440 2A EA PP 1.2.7.1 (45 min. time limit). Discuss with class after completed.	G. Work sample problem.

1. Results of SCBT 440 2A EA PP 1.2.7.1

REQUIRED:

a. Plot the dry density vs. molding water content curves.

b. What is the maximum dry density at modified AASHO compaction? 130 lb/cu.ft.

c. What is the dry density at 95% modified AASHO maximum dry density? 123.5 - lbs/cu.ft.

d. Plot the corrected CBR vs. molding water content curves.

e. What is the maximum corrected and soaked CBR at modified AASHO compaction? 35.2 %.

f. Plot the corrected CBR vs Dry density curves for Molding Water Contents of 7, 9, and 11 percents.

g. Determine the design at 95% of modified AASHO maximum dry density and at the molding water content within ± 2% of OMC. Design CBR = 9%

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
III. Application		
A. Discussion	III.A. Questions	III.A. Answers
	a. What material is used as a standard for judging the CBR of a material?	a. Limestone.
	b. What size mold is used?	b. 6 in diameter, 7 in. high.
	c. What size material is used to replace that retained on the 3/4 inch sieve?	c. That passing 3/4 inch and retained on a #4 sieve.
	d. What is the standard load for 0.1 inches of penetration?	d. 1000 lbs.
B. Practical performance:	III.B. Read and explain Criterion Test. Pass out required forms and have student perform CBR test.	III.B. Perform CBR test.
1. Conduct CBR test on soil samples obtained from exploration (use 10 lb load).		
IV. Summary		
A. Definition.		
B. CBR test.		
C. Equipment.		
D. Preparation of remolded samples		
E. Penetration test.		

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

F. Test procedures for remolded samples.

V. Test.

A. None

SCBT 440.2A EA PP 1.2.7.1.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043

PRACTICE PROBLEM

Title: California Bearing Ratio

Objective: To provide the student with a knowledge of the principles and procedures for correcting a penetration curve.

Time: 45 minutes.

Situation: You have analyzed a representative soil sample at the proposed site of construction, and have both the laboratory compaction and CBR penetration tests. You have the following incomplete information.

How would you complete?

COMPACTION TEST DATA

Molding Water Content, %		Dry Density lbs/cu. ft.		
		55 Blow Compaction	26 Blow Compaction	12 Blow Compaction
6.4		118.8	112.5	104.0
7.4		125.0	117.5	108.5
9.0		130.0	123.0	114.5
10.4		126.5	121.5	117.0
11.6		120.0	115.5	113.0
12.6		112.0	110.0	107.0
9.8	Extra point	-----	123.5	-----

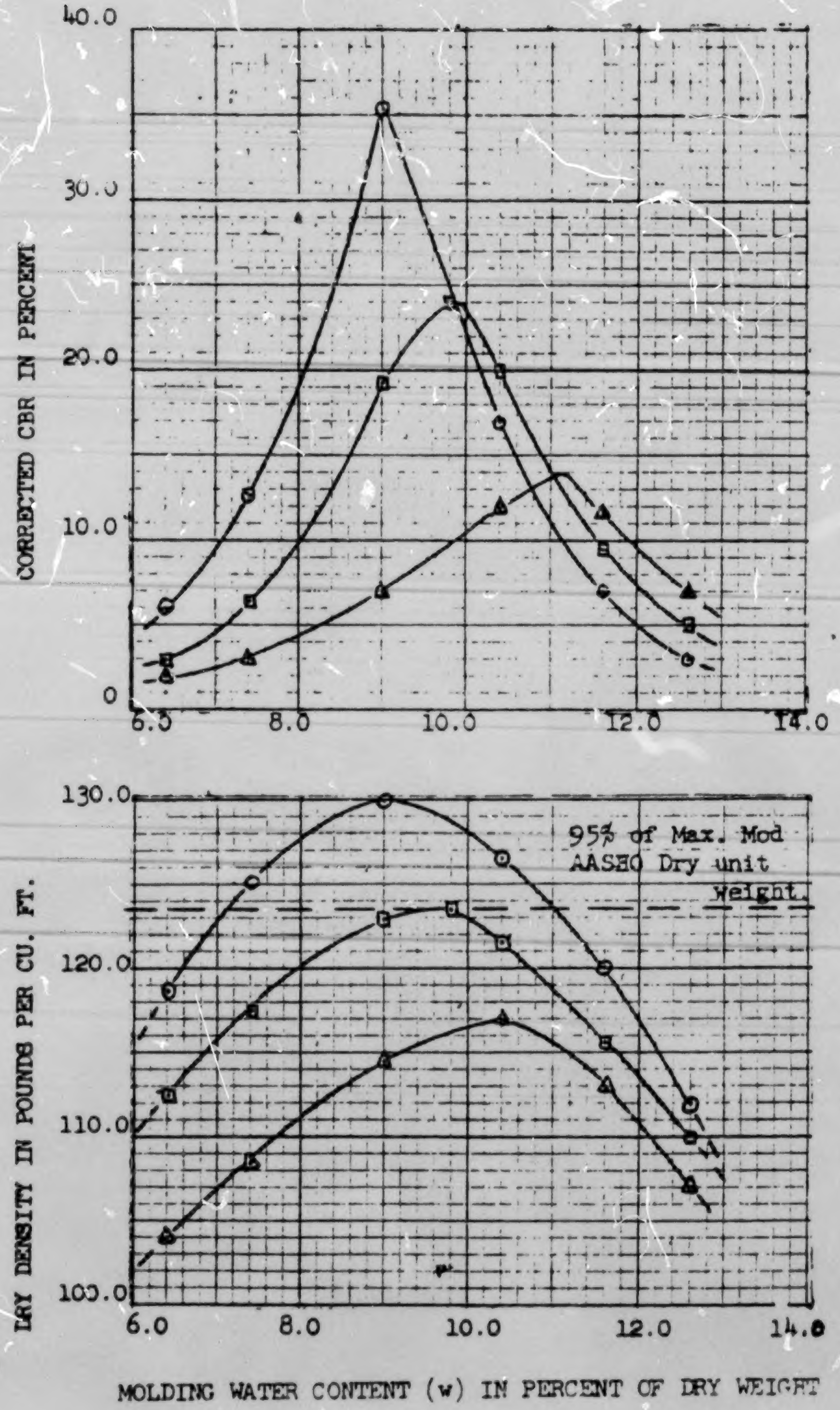
a. Each of the compacted specimens were next soaked for four days, drained for 15 minutes, and then the corrected CBR of each of the specimens were determined from the penetration test. See the Table below.

PENETRATION TEST DATA

Molding Water Content, %		Corrected CBR in Percent		
		55 Blow Compaction	26 Blow Compaction	12 Blow Compaction
6.4		6.0	3.0	2.0
7.4		12.5	6.4	3.0
9.0		35.2	19.2	7.0
9.8	Extra point	----	24.0	---
10.4		17.0	20.0	12.0
11.6		7.0	9.5	11.5
12.6		3.0	5.0	7.0

REQUIRED:

1. Plot the dry density vs. molding water content curves.
2. What is the maximum dry density at modified AASHO compaction?________________________lb/cu.ft.
3. What is the dry density at 95% modified AASHO maximum dry density?_____________lbs/cu.ft.
4. Plot the Corrected CBR vs. Molding Water Content curves.
5. What is the maximum corrected and soaked CBR at modified AASHO compaction?_________________%.
6. Plot the Corrected CBR vs Dry Density curves for Molding Water Contents of 7, 9, and 11 percents.
7. Determine the design CBR at 95% of modified AASHO maximum dry density and at the Molding Water Content within ± 2% of OMC?


40.0
30.0
20.0
10.0
0
CORRECTED CBR IN PERCENT
6.5
8.0
10.0
12.0
14.0
130.0
120.0
110.0
100.0
DRY DENSITY IN POUNDS PER CU. FT.
95% of Max. Mod AASHO Dry unit Weight.
6.0
8.0
10.0
12.0
14.0
MOLDING WATER CONTENT (w) IN PERCENT OF DRY WEIGHT

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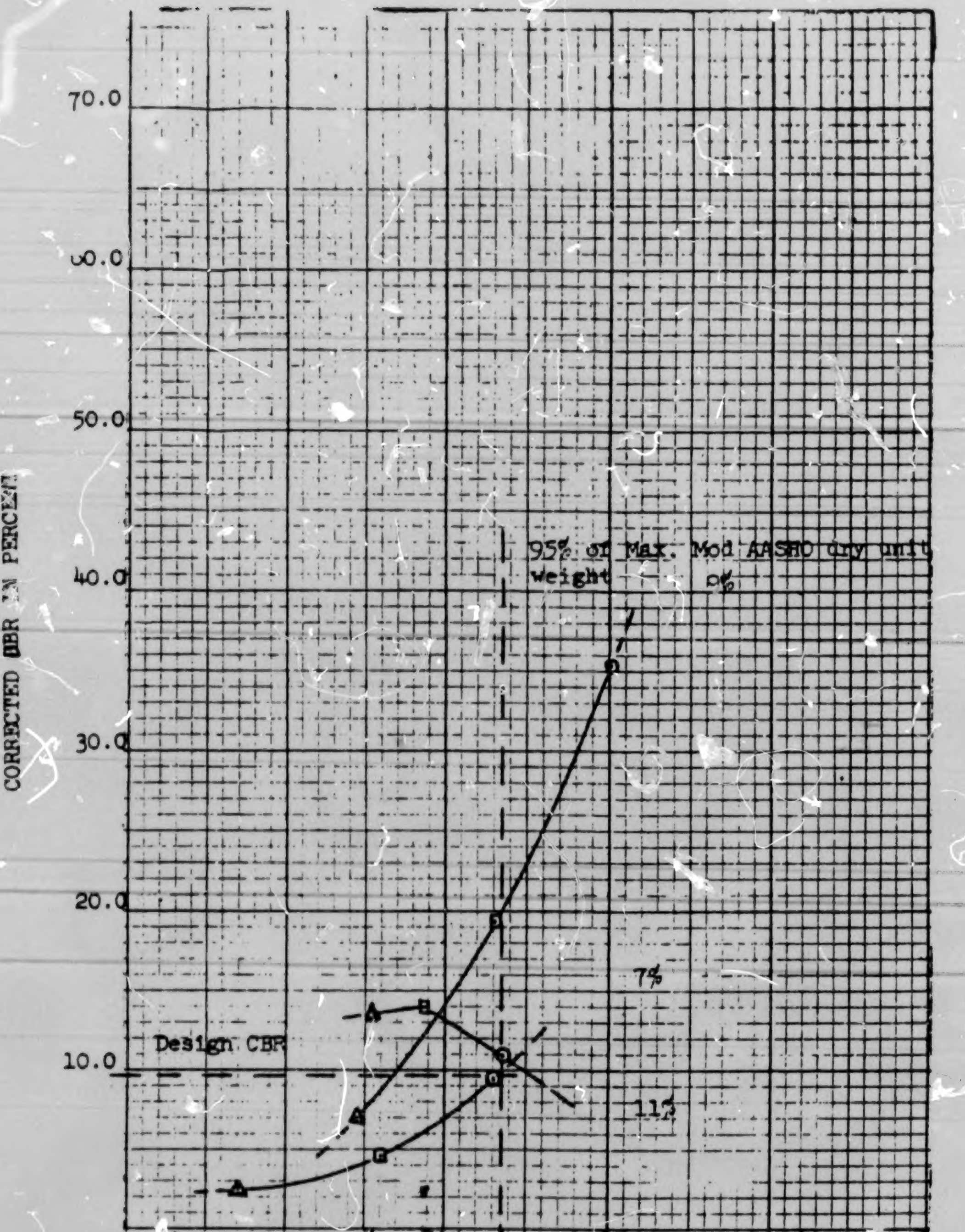
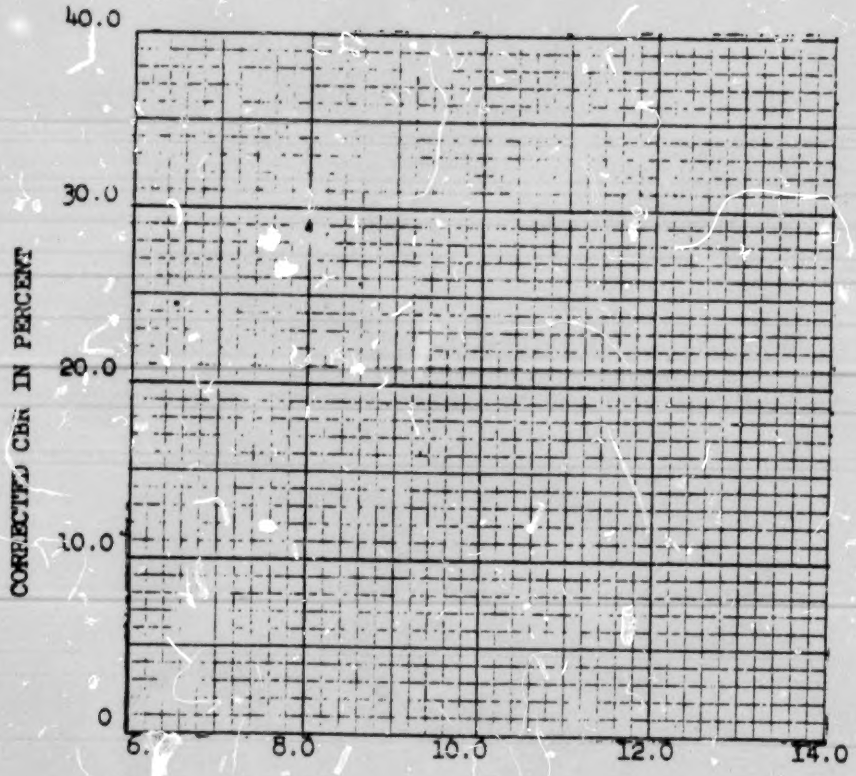
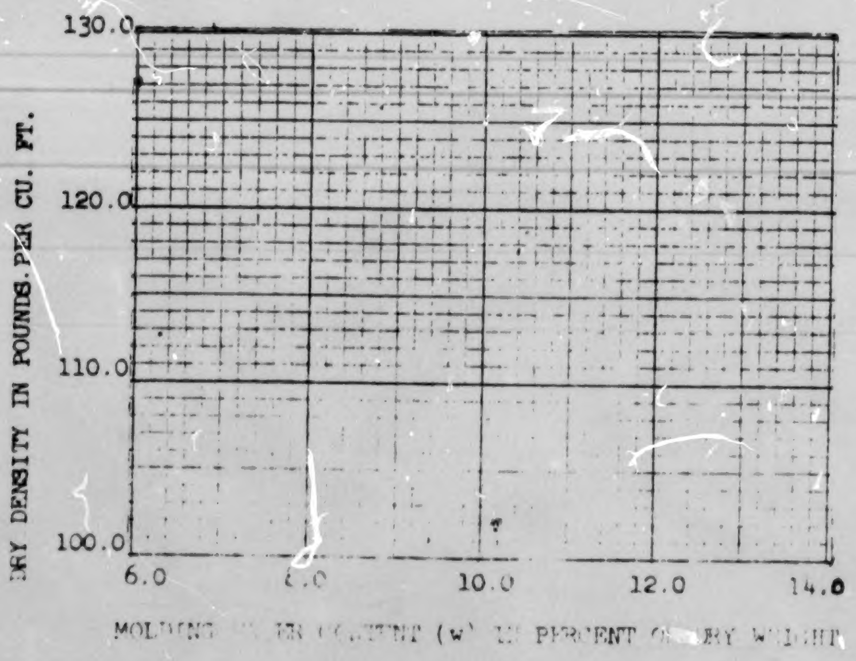

70.0
60.0
50.0
40.0
30.0
20.0
10.0
CORRECTED CBR IN PERCENT
95% of Max. Mod AASHO dry unit weight
9%
7%
11%
Design CBR
100.0
110.0
120.0
130.0
140.0
150.0
MOLDED DRY DENSITY IN POUNDS PER CU FT

(4 of 6)


CORRECTED CBR IN PERCENT
40.0
30.0
20.0
10.0
0
6.0
8.0
10.0
12.0
14.0


DRY DENSITY IN POUNDS PER CU. FT.
130.0
120.0
110.0
100.0
6.0
8.0
10.0
12.0
14.0
MOLDING WATER CONTENT (w) IN PERCENT OF DRY WEIGHT

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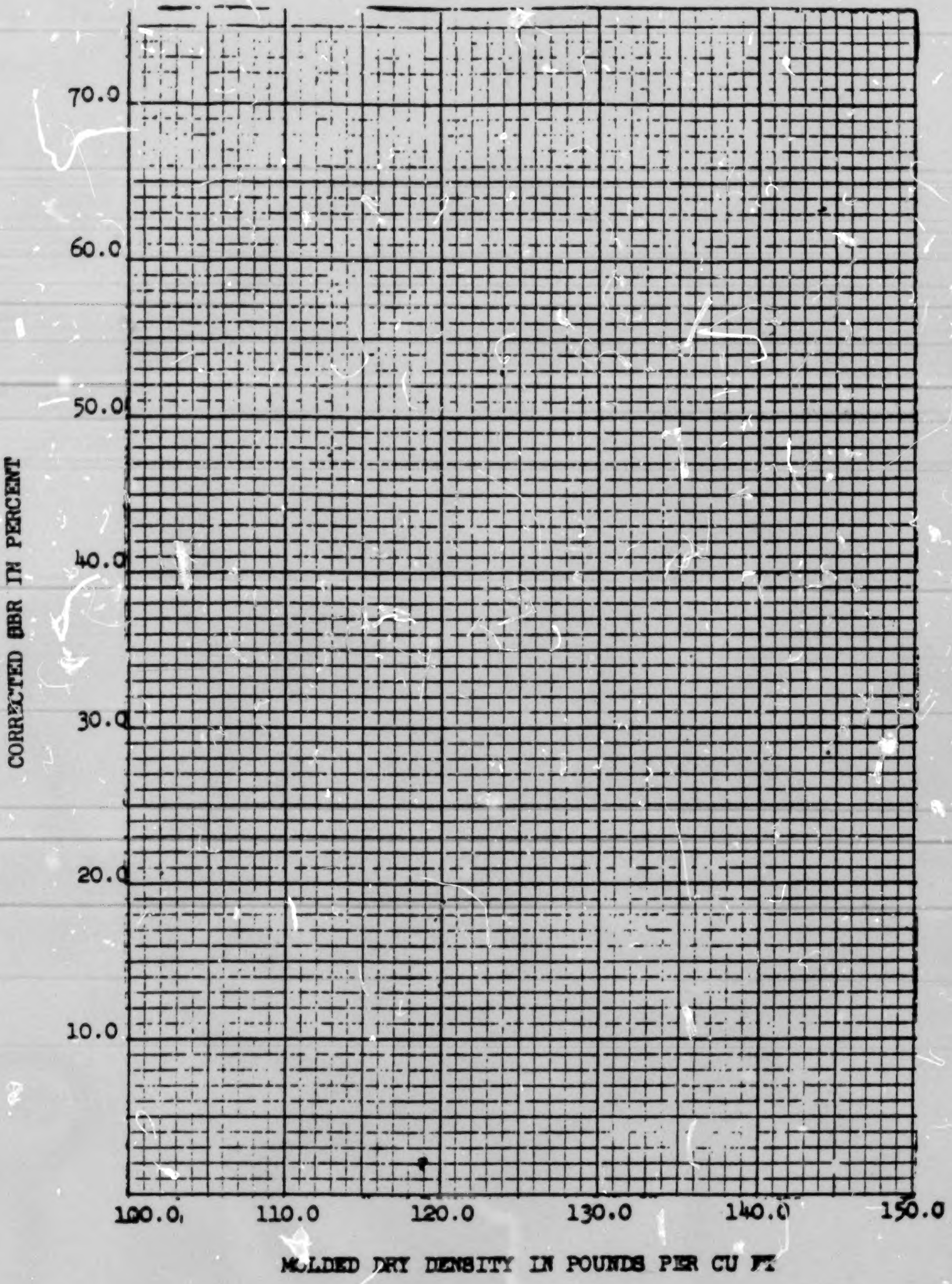
70.0
60.0
50.0
40.0
30.0
20.0
10.0
CORRECTED CBR IN PERCENT
100.0
110.0
120.0
130.0
140.0
150.0
MOLDED DRY DENSITY IN POUNDS PER CU FT

(6 of 6)

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUNEME, CALIFORNIA 93043
SPECIAL CONSTRUCTION BATTALION TRAINING (SCBT) 440.2A

Classification: Unclassified

Topic: Soils Exploration Report.

Average Time: 1 Period (Class), 4 Periods (Pract)

Instructional Materials:

A. Text:

1. None

B. Reference:

1. Sample Technical Soils Report for use in SANLAC S.002-556 Feb 1970, U.S. Army Engineers School

C. Tools, Equipment and Materials:

1. See Annex III.

D. Training Aids and Devices.

1. Films: None

2. Transparencies: None

3. Charts: None

4. Locally Prepared Material:

a. Information Sheet.

(1) SCBT 440.2A EA IS 1.2.8.1, "Sample Soils Report".

Terminal Objective: Upon completion of this unit each student will have explored, identified, classified and stabilized soils. Conditions, standards and procedures for each of the related topics leading to the successful completion of this terminal objective shall be as set forth in each topic.

Enabling Objectives: Upon completion of this topic, each student while working as a member of a team (not to exceed four (4) members) will be able to assemble a "Soils Exploration Report". Students will use their test data from all topics in this unit to develop this report. The format and procedures shall be as set forth in this instructor guide and student information sheet SCBT 440.2A EA IS 1.2.8.1, "Soils Exploration Report". All student responses should be neatly hand written. This topic is not intended to be restrictive but student responses should be 100 percent accurate after checking and discussing with the class instructor.

Criterion Test: Each student while working as a member of a team (not to exceed four (4) members) will be able to assemble a "Soils Exploration Report". Students will use their test data from all topics in this unit to develop this report. The format and procedures shall be as set forth in this instructor guide and student information sheet SCBT 440.2A EA IS 1.2.13.1, "Soils Exploration Report". All student responses should be neatly hand written. This topic is not intended to be restrictive but student responses should be 100 percent accurate after checking and discussing with the class instructor.

Homework: None

E. Training Aids Equipment: None.

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OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the Lesson		
A. Establish contact	I A Introduce self and topic	
1. Name:		
2. Topic: Soils Exploration Report		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Quality Control Technician.		
D. Overview.	I.D. State learning objectives	
1. You will be able to assemble a Soils Exploration Report.	a. State information and materials necessary to guide student.	
2. Ask questions.		
3. Take notes.		
4. Testable.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
II. Presentation.		
A. The soils report is written evaluation of the site as developed from preliminary and laboratory investigation.		
1. Provides the engineer with a concise, readily available source of information.		
2. Reference for follow on personnel.	II.A.2. As a reference to determine corrective measures necessary in order to stabilize existing soil before construction work (if needed).	
3. Helps evaluate later problems which may arise during construction.		
B. The report - Composition of:	II.B. Pass out SCBT 440.2A EA IS 1.2.8.1	II.B. Follow along in Information Sheet.
1. Section I - Project.		
a. General description.		
b. Authority for and extent of proposed construction.		
c. Purpose and scope of report.		
2. Section II - Preliminary Investigation.		
a. Site description.		
(1) Location and existing facilities.		
(2) Existing conditions.		
(a) Topography.		
(b) Vegetation.		
(c) Drainage.		

b. Climate.

c. Geology.

d. Aggregates.

3. Section III Investigation Results.

a. Field investigation (subgrade soils)

(1) Test Borings.

(2) In-place density and in-place moisture content.

(3) Field CBR/pentrometer.

(4) Field identification.

b. Laboratory investigation.

(1) Sieve analysis.

(2) Atterburg limits.

(3) Specific Gravity .

(4) Compaction and California Bearing Ratio.

(5) Continue with any other test conducted.

c. As Construction proceeds, add all field and lab test results.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
4. Section IV Conclusions and Recommendations.		
a. Possible problem areas.		
b. Conclusions.		
c. Recommendations.		
d. Lessons learned.		
e. Etc.		
5. Section V Design Date - Engineer Provided and Approved Data		
6. Annexes.		
a. General plan/sketch of area.		
b. Location Plan.		
c. Boring logs and soil profile.		
d. Cross sections for structures.		
e. All test data - (Field and lab.)		
f. All design data.		

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
III. Application.		
A. Discussion to be developed by the instructor.	A. Questions.	A. Answers.
B. Practical performance:	B. Read and explain Criterion Test, have student take their test results and as a team develop a soils report for each team.	B. Develop soils report.
1. Develop soils report.		
IV. Summary		
A. Introduction.		
B. The Report - Composition of.		
V. Test.		
A. None.		

DEPARTMENT OF THE NAVY
HEADQUARTERS 32nd ENGINEER GROUP
CLASS 51G20/2-5
FORT BELVOIR, VIRGINIA

SOILS EXPLORATION REPORT FOR PROPOSED AIRFIELD

10 OCTOBER 1974

To: Commaning Officer, HQ 1st Engineer Brigade, Fort Belvoir, Va.

Via: Major Sergio Q. Drillock, 2-3, 32nd Engineer, Fort Belvoir, Va.

Via: Soils Section Chief for compiling data from groups (1) one thru (5) five.

Submitted by Group (5) five.

E7/GYSGT	Joseph S. Neal, USMC
E5/EA2	David L. Lewis, USN *
E3/PFC	Lawrence H. Sackrider, USA
E2/PVT	Jack D. Oest, USA
E2/PVT	Michael R. King, USA **

* Class Leader.
** Group 5 Leader

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DEPARTMENT OF THE NAVY
HQ 1st Engineer Brigade
Fort Belvoir, Virginia

Subject: Job Directive No. 1-73

CO, 32 Engineer Gp. (Const.)

1. You will design and construct a medium load airfield between Coordinate: 18SUTo9318475 (Station 00 + 00) and Coordinates: 18SUT093444 (Station 10 + 00.

2. Location: As above. See enclosed map sheet. (Incl. 1)

3. Time: Design and construction estimates will be completed by 26 March 1975. Project completion data is 30 June 1975. Design cross-sections to be approved by this Headquarters prior to start of construction.

4. Asphalt production and laydown will be accomplished by the 104th Engineer Co. (CS) Direct coordination is authorized. No additional Bde. assets will be allocated for this project.

5. Land use requests for use of borrow material will be submitted in accordance with BDE SOP.

6. Priority A (See BDE SOP)

7. CPM schedules and reports will be submitted in accordance with BDE SOP.

8. Project officer from this HQ is MAJ Thoms, Asst. S-3 1st Eng. BDE. Telephone 44974/44988. Direct coordination is authorized.

For the Commander

STEVEN PONCIN
CPT AG
Asst. Adj.

INCL 1: Map Sheet, Special Map ED, 1 TPC Fort Belvoir

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SCBT 440.2A EA IS 1.2.8.1

HEADQUARTERS 32nd ENGINEER GROUP
FORT BELVOIR, VA.

MEMORANDUM

To: Chief
Soils Section

1. This group has been assigned the mission of designing and constructing an airfield as shown in the attached Job Direction.

2. In order to accomplish this construction and design, information concerning the subgrade soils is required.

3. You are assigned the task of analyzing the subgrade soils and submitting a written technical report by 10 Oct 1974.

4. The report will be prepared in accordance with established procedures and will include as a minimum:

   a. The in-place density of the subgrade.
   b. The in-place moisture content of the subgrade.
   c. The gradation of the soil.
   d. The Atterburg Limits.
   e. The specific gravity of the soil.
   f. The Modified AASHO Compaction data.
   g. Design CBR at 90-95% compaction and 95-100% compaction.
   h. Optimum Moisture Content range for the Design CBRs.
   i. The soil profile along the center line of the airfield to a depth of 10 feet below the existing surface.

SERGIO Q. DRILLOCK
MAJ CE

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I. JOB DIRECTIVE:

As per enclosures (1) one and (2) two of pages one and two, groups one thru five of class 51G20/2 have been authorized to analize the subgrade soil for job directive no. 1-73. The findings of group five are shown in the following pages of this report.

II. PROJECT: (See enclosure one and two on pages one and two.)

A. General Description: Located in the NW section of the Fort Belvoir Military Reservation between coordinates 18SUT9398444 and 18SUT09318476, a medium airfield will be designed and constructed.

B. Authority and extend of proposed construction:

Authority for this project is granted in job directive No. 1-73 of HQ 1st Engineer Brigade, Fort Belvoir, Virginia.

C. Purpose and Scope of Report:

The purpose of this report is to analize the subgrade soils along and about the centerline of the proposed airfield between stations 10+75 and 11+75. Preliminary design will be based on the data obtained in this report. The final design will be compiled by the soils section chief and the S-3 officer. Sources for data obtained herein are from field sampling and testing and laboratory testing.

III. PRELIMINARY INVESTIGATIONS:

A. Site Description: See project general description page 3.

B. Existing Description:

1. Topography: Centerline of proposed site is gradually sloping to the north with about a 1% slope.
2. Vegetation: This project site consists of grass, underbrush, and trees of both hard and soft wood with a diameter range

from three to twelve inches.

3. Climate: Average year round temperature is from 25 to 85 degrees fahrenhait. Average rainfall is 41.1 inches. Further information is contained in student handout of February 1970 (S.002-556) Page 3.

4. Geology: See student handout S.002-556 Page 3.

5. Aggregates: See student handout S.002-556 Page 3.

IV. FIELD INVESTIGATIONS: (Subgrade Soil)

A. Test Borings: Test Borings were made with a hand auger on 2 October 1974. Results appear in the boring log entries on pages ___thru ___ and on plan profile sheet, Page ______.

B. In Place Density and In Place Moisture Content:

1. Sand Cone Method: Two tests were done with the following average results:

Dry Density 96.36 Lbs/Cu. Ft.

Moisture Content 19.20 %

2. Nuclear Densometer: Taken in place with the following results:

Dry Density 91 lbs./Cu.Ft.

Moisture Content 24.18 %.

C. Field Identification: Shows subgrade material to be a CL (Low compressive clay) See Page 15 .

V. LABORATORY INVESTIGATIONS: (Subgrade soil)

A. Sieve Analysis: A representative sample of 1500 grams was used. Results are as follows:

Sieve Size	Percent Passing
No. 4	100%
No. 10	99.7%
No. 40	93.8%

No. 60	88.4%
No. 100	84.1%
No. 200	76.4%

Gravel 00 %
Sand 23.6 %
Fines 76.4 %
100.0

See pages 16 and — for sieve analysis chart

Gradation was not a factor due to a large percent of fines, therefore, no grain size distribution graph is submitted.

Cc and Cu were unattainable because the fines were greater than 50%.

B. Atterburg Limits: Material is a low compressive clay (CL) see liquid and plastic limit chart page 17.

LL - 39.56
PL - 22.85
PI - 16.71

C. Hydrometer Analysis: It was determined that the dubgrade material (CL) to be highly frost susceptable by 100 %. See Pages 17 and 18.

D. Specific Gravity: This was determined to be 2.73 as per say of Lt. Knauss.

E. Compaction and California Bearing Ratio:

An expedient method was used to estimate optimum moisture content at Approximately 19.2 % for the sample at borehole #5, Sta. 11+50. Then compaction molds at various moisture contents about the estimated OMC were made with compactive efforts of 55, 26, and 12 blows per layer. The compaction data can be found on pages 19 — 24. Compaction curves are on pages 23 — 48. The molds were soaked for four days and swell readings were taken at the end of the fourth day and then penetration tests were run. Results are on pages ______

Design CBR: From the compaction curves it was determined that OMC was ________% and a corresponding maximum modified AASHO dry density of ______ Using this data of curves for moisture content ranging from ___________% to ________% was developed.

Using the family of curves, design CBR's were determined for both the 90 - 95 - 100% composition. Results are as follows:

Then picking the lowest moisture content range, the lowest CBR values were used. Results are as follows:

This date yields the design CBR and moisture content ranges as follows:

% COMPACTION	DESIGN CBR	MOISTURE CONTENT

CONSTRUCTION BRANCH
DEPARTMENT OF ENGINEERING
FORT BELVOIR, VIRGINIA

REPORT OF FOUNDATION AND BORROW INVESTIGATION

SITE Job Directive No. 1-73 TYPE EXPLORATION HASTY DATE 2 Oct 1979

BORING NO. 1 LOCATION STA 10+50 GROUND ELEV. 100.00'

PURPOSE OF EXPLORATION DETERMINE SOIL CHARACTERISTICS OF FOUNDATION FOR PROPOSED AIRFIELD

DEPTH BELOW SURFACE 1"=	ELEV.	SAMPLE NO & TYPE	GRAPHIC LOG	GROUP SYMBOL	DESCRIPTION, TEST DATA, & REMARKS
.25'		1	▨	OH	ORGANIC CLAYS OF MEDIUM PLASTICITY
2' 4' 4.5'		2	▨	CL	LOW COMPRESSIVE CLAYS YELLOWISH BROWN IN COLOR
6' 7.25'		3	▥	SM	SANDY SILTS REDDISH BROWN WITH L[illegible]SS OF WHITE
8' 8.9		4	▨	CL	LOW COMPRESSIVE CLAY BROWNISH WHITE IN COLOR
10'		5	■	CH	HIGH COMPRESSIVE CLAY, VERY MOIST, WHITE IN COLOR

DEPTH TO WATER TABLE 9.0'
ELEV. 91.00'

SUBMITTED BY GROUP #1

22.503—Ft Belvoir

SC31 440.2A EA IS 1.2.C.1

CONSTRUCTION BRANCH
DEPARTMENT OF ENGINEERING
FORT BELVOIR, VIRGINIA

REPORT OF FOUNDATION AND BORROW INVESTIGATION

SITE JOB DIRECTIVE NO. 1-73 TYPE EXPLORATION HASTY DATE 2 OCT 1974

BORING NO. 2 LOCATION STA 10+75 GROUND ELEV. 100.4'

PURPOSE OF EXPLORATION DETERMINE SOIL CHARACTERISTICS OF FOUNDATION FOR PROPOSED AIRFIELD.

DEPTH BELOW SURFACE 1" = ___	ELEV.	SAMPLE NO & TYPE	GRAPHIC LOG	GROUP SYMBOL	DESCRIPTION, TEST DATA, & REMARKS
2' 4'	96.4	1	▨	CL	LOW COMPRESSIVE CLAY - YELLOWISH BROWN IN COLOR - SOME FINES, NO GRAVEL.
6' 6.7'	93.5	2	▒	MH	INORGANIC, ELASTIC SILTS REDDISH BROWN IN COLOR
8' 10	90.4	3	▨	CL	LOW COMPRESSIVE WHITISH CLAY

DEPTH TO WATER TABLE 8.00'
ELEV. 92.40'

SUBMITTED BY GROUP #2

(10 of 49)

22,503—Ft Belvoir

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CONSTRUCTION BRANCH
DEPARTMENT OF ENGINEERING
FORT BELVOIR, VIRGINIA

REPORT OF FOUNDATION AND BORROW INVESTIGATION

SITE Log Directive No. 1-73 TYPE EXPLORATION HASTY DATE 2 OCT. 1974

BORING NO. 3 LOCATION STA 11+00 GROUND ELEV. 101.50

PURPOSE OF EXPLORATION DETERMINE SOIL CHARACTERISTS OF FOUNDATION FOR PROPOSED AIRFIELD.

DEPTH BELOW SURFACE 1" =	ELEV.	SAMPLE NO & TYPE	GRAPHIC LOG	GROUP SYMBOL	DESCRIPTION, TEST DATA, & REMARKS
1'	100.5'	1	▨	OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY
2' 2.2'	99.3	2	▨	CL	LOW COMPRESSIVE CLAY YELLOWISH BROWN IN COLOR
4'	97.5'	3	▨	SC	SANDY CLAY REDDISH IN COLOR
6' 8' 8.25	93.25	4	▨	SM	SANDY SILTS REDDISH IN COLOR
10'	91.5	5	▨	CL	LOW COMPRESSIVE CLAY BROWNISH WHITE IN COLOR

DEPTH TO WATER TABLE 94.0

SUBMITTED BY GROUP # 3

(11 of 49)

22,503—Ft Belvoir

CONSTRUCTION BRANCH
DEPARTMENT OF ENGINEERING
FORT BELVOIR, VIRGINIA

REPORT OF FOUNDATION AND BORROW INVESTIGATION

SITE Job Directive No. 1-73 TYPE EXPLORATION HASTY DATE 2 OCT 1979

BORING NO. 4 LOCATION STA. 11+25 GROUND ELEV. 101.85'

PURPOSE OF EXPLORATION DETERMINE SOIL CHARACTERISTS OF FOUNDATION FOR PROPOSED AIRFIELD.

DEPTH BELOW SURFACE 1" = ___	ELEV.	SAMPLE NO & TYPE	GRAPHIC LOG	GROUP SYMBOL	DESCRIPTION, TEST DATA, & REMARKS
1'	100.85	1	▥	ML	~~INORGANIC SILT WITH VERY FINE~~ SAND, LIGHT BROWN IN COLOR
2' 4' 5.5'	96.35	2	▨	CL	LOW COMPRESSIVE CLAY YELLOWISH BROWN IN COLOR
6' 8' 8.5	93.35	3	▥	SM	SANDY SILTS REDDISH IN COLOR
10'		4	▩	CH	HIGH COMPRESSIVE CLAYS WHITE IN COLOR

DEPTH TO WATER TABLE 6.00' ELEV = 95.85

SUBMITTED BY GROUP #4

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CONSTRUCTION BRANCH
DEPARTMENT OF ENGINEERING
FORT BELVOIR, VIRGINIA

REPORT OF FOUNDATION AND BORROW INVESTIGATION

SITE See Directive No. 1-73 TYPE EXPLORATION HASTY DATE 2 OCT 1979

BORING NO. 5 LOCATION STA. 11+50 GROUND ELEV. 101.5'

PURPOSE OF EXPLORATION DETERMINE SOIL CHARACTERISTICS OF FOUNDATION FOR PROPOSED AIRFIELD.

DEPTH BELOW SURFACE 1" = ___	ELEV.	SAMPLE NO & TYPE	GRAPHIC LOG	GROUP SYMBOL	DESCRIPTION, TEST DATA, & REMARKS
.75'	100.75	1	▨	SC	SANDY CLAY BROWNISH IN COLOR
2' 2.2'	99.3'	2	▨	CL	LOW COMPRESSIVE CLAY YELLOWISH BROWN IN COLOR
3.9'	97.6	3	▥	SM	SANDY SILT REDDISH BROWN IN COLOR
4' 4.8'	96.7	4	▨	SC	SANDY CLAY WHITISH BROWN IN COLOR
5.2'	96.3	5	▥	SM	SANDY SILT WHITISH BROWN IN COLOR
6' 6.8'	94.7	6	▨	SC	SANDY CLAY REDDISH IN COLOR
8' 8.2'	93.3	7	▥	SM	SANDY SILT REDDISH IN COLOR
9'	92.5	8	▥	SM	SANDY SILT VERY MOIST REDDISH IN COLOR
10'	91.5	9	▨	CL	LOW COMPRESSIVE CLAY WHITE IN COLOR, VERY MOIST.

DEPTH TO WATER TABLE 5.00'
ELEV =96.5'

SUBMITTED BY GROUP #5
Lewis

(13 of 49)

22.503—Ft Belvoir

FIELD IDENTIFICATION

Bore Hole #5

Sta. 11+50

TEST	#1	#2	#3
Sedimentation	70% S	45% S	85% S
Comparison	0% G, 70% S, 30% F	0% G, 35% S, 65% F	0% G, 85% S, 15% F
Dry Strength	M	CL	M
Powder	C	C	M
Feel	C	C	M
Shine	S	CL	M
Thread	C	C	M
Ribbon	S	CL	M
Bite	C	C	M
Wet Shaking	C	C	M
Odor	None	None	None
CLASSIFICATION	SC	CL	SM

TEST	#4	#5	#6
Sedimentation	60% S	40% S	75% S
Comparison	0% G, 60% S, 40% F	0% G, 40% S, 60% F	0% G, 75% S, 25% F
Dry Strength	CL	M	CL
Powder	C	M	C
Feel	C	M	C
Shine	S	S	S
Thread	C	M	C
Ribbon	S	S	S
Bite	C	M	C
Wet Shaking	C	M	C
Odor	None	None	None
CALSSIFICATION	SC	SM	SC

TEST	#7	#8	#9
Sedimentation	60% S	65% S	40% S
Comparison	0% G, 60% S, 40% F	0% G, 65% S, 35% F	0% G, 40% S, 60% F
Dry Strength	M	M	CL
Powder	M	M	C
Feel	M	M	C
Shine	S	S	CL
Thread	M	M	C
Ribbon	S	S	CL
Bite	M	M	C
Wet Shaking	M	M	C
Odor	None	None	None
CLASSIFICATION	SM	SM	CL

WATER CONTENT DETERMINATION

	UNITS					
TARE NUMBER						
15. WEIGHT WET SOIL & TARE						
16. WEIGHT DRY SOIL & TARE						
17. WEIGHT WATER (15.-16.)						
18. WEIGHT TARE						
19. WEIGHT DRY SOIL (16.-18.)						
20. WATER CONTENT ($\frac{17}{19}$ x 100)						
21. AVERAGE WATER CONTENT	PERCENT	18.00%		20.40%		(SPEEDY)

UNIT WEIGHT DETERMINATION

	UNITS			
TARE NUMBER		TEST # 1	TEST # 2	
22. WEIGHT WET SOIL & TARE	Gm	4205.0	4375.0	
23. WEIGHT TARE	Gm	373.6	373.6	
24. WEIGHT WET SOIL (22.-23.)	Gm	3831.4	4001.4	
25. WET UNIT WEIGHT (24./14.)	LB./CU. FT.	109.6	120.24	
26. DRY UNIT WEIGHT (25. x $\frac{100}{100+21.}$)	LB./CU. FT.	92.87	99.86	

REMARKS

CLEAR, COOL, SLIGHTLY WINDY
RAINED THE NIGHT BEFORE THUS INCREASING
MOISTURE CONTENT.

TECHNICIAN (Signature)	COMPUTED BY (Signature)	CHECKED BY (Signature)
NEEL KING SOCKRIDER	DEST	LEWIS

U. S. GOVERNMENT PRINTING OFFICE 1957 O—443855

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UNIT WEIGHT DETERMINATION **"VOLUME OF HOLE" METHODS**	DATE 2-Oct. 1973

PROJECT JOB DIRECTIVE No. 1-73	TEST SITE STA. 11+50 GROUP #5	SAMPLE NUMBER E[illegible]5-7

ADDITIONAL SPECIFICATIONS

TEST DONE ON SUBGRADE MATERIAL ONLY

CONVERSION FACTORS

1 in. = 2.54 cm.
1 lb. = 453.6 gm.
1 gm./cc. or 62.4 lb./cu. ft. = Unit weight of water
1 cu. ft. = 1728 cu. in.

CALIBRATION OF STANDARD MATERIAL	STANDARD MATERIAL (Check one) ☒ SAND ☐ OIL ☐ OTHER (Specify)				
	UNITS				
APPARATUS OR TARE NUMBER		1	2		
1. WEIGHT OF APPARATUS OR TARE FILLED	Gm	5850	5841		
2. WEIGHT OF APPARATUS OR TARE EMPTY	Gm	4373	4373		
3. WEIGHT OF MATERIAL (1.-2.)	Gm	1477	1468		
4. VOLUME OF APPARATUS OR TARE	FT³	1/30	1/30		
5. UNIT WEIGHT OF MATERIAL (3./4.)	LBS.	[illegible]	97.00		
6. AVERAGE UNIT WEIGHT OF MATERIAL	LB./CU. FT.	97.30		AVERAGE	
CALIBRATION OF APPARATUS		TEMPLATE NUMBER		CONE NUMBER	
	UNITS				
7. INITIAL WEIGHT OF APPARATUS + SAND	Gm	7865	7730		
8. FINAL WEIGHT OF APPARATUS + SAND	Gm	6033	5960		
9. WEIGHT OF SAND IN TEMPLATE AND/OR CONE	Gm	1832	1770		
"VOLUME OF HOLE"					
	UNITS				
10. INITIAL WEIGHT OF APPARATUS + MATERIAL	Gm	7651	7537		
11. FINAL WEIGHT OF APPARATUS + MATERIAL	Gm	2399	2525		
12. WEIGHT OF MATERIAL RELEASED (10.-11.)	Gm	5252	5012		
13. WEIGHT OF MATERIAL IN HOLE (For oil, same as 12. For sand, 12.-9.)	Gm	3420	3242		
14. VOLUME OF HOLE (13./6.)	FT³	.077	.073		

DD FORM 1215

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HEAVY CONSTRUCTION BRANCH
DEPARTMENT OF ENGINEERING AND MILITARY SCIENCE
U.S. ARMY ENGINEER SCHOOL
FORT BELVOIR, VIRGINIA

SIEVE ANALYSIS (STUDENT PE)

Submitted by GROUP #5 Date performed 3 OCT - 7 OCT. 1974

Description of sample CL - LOW COMPRESSIVE CLAY, YELLOWISH BROWN IN COLOR.

Wt. original sample 1500 gm.

Wt. after prewashing 400 gm.

Washing loss .... 1100 gm.

Test performed by:
1. SACKRIDER
2. KING
3. NEAL
4. OEST
5. LEWIS

Sieve or screen	Sieve Opening (mm.)	Wt. of sieve (gm.)	Wt. of sieve & sample (gm.)	Wt. retained on sieve (gm.)	Passing sieve Weight in (gm.)	 Percent	
*				0		100	Gravel 0%
2"	50.8	—	—	—	—	—	
1 1/2"	38.1	—	—	—	—	—	
1"	25.4	—	—	—	—	—	
3/4"	19.1	—	—	—	—	—	
1/4" (No. 3)	6.35	—	—	—	—	—	
No. 4	4.76	—	—	—	1495	100.0	Sand 23.6%
No. 10	2.00	484	489	5	1490	99.7	
No. 40	0.42	546	633	87	1403	93.8	
No. 60	0.25	342	423	81	1322	88.4	
No. 100	0.149	353	418	65	1257	84.1	
No. 200	0.074	484	599	115	1142	76.4	Fines 76.4%

Wt. retained in pan 42 gm.

Washing loss . . . 1100 gm.

Pan total . . . . 1142 gm.

Total weight of fractions . . . . . 1495 gm.

Error=Original Wt. -Total weight of fractions 5 gm. 0.333 %

*Maximum particle size (measured)
Prepared for use at [illegible]

SCBT 440.2A EA IS 1.2.3.1

LIQUID and PLASTIC LIMITS

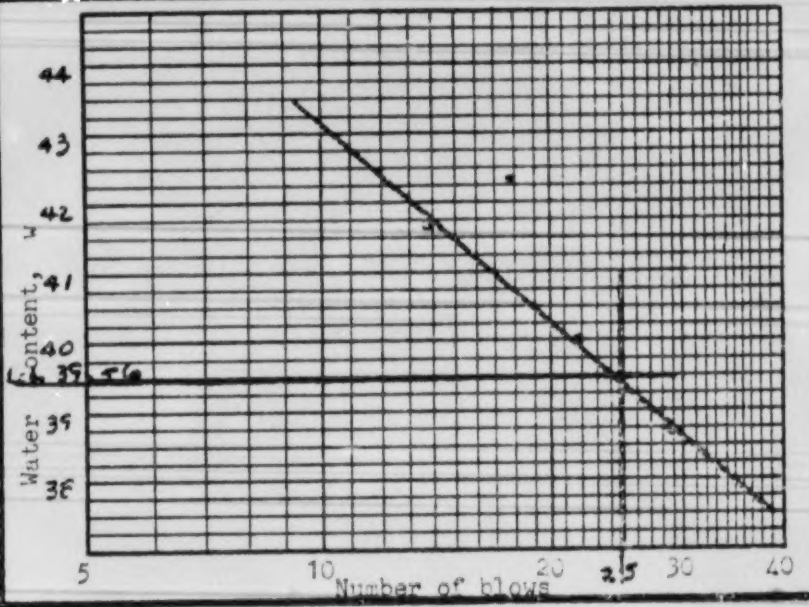
DATE 4 OCT 1974

PROJECT L.C. DIRECTIVE NO. 1-73

BORING NO STA 11+50 QUARRY #5 SAMPLE NO #5-7

LIQUID LIMIT

RUN NO.		1		3	4	5	
TARE NO.		5-7	5-3	5-1	5-35	5-7	5-13
Weight in grams	Tare plus wet soil	33.0	33.7	31.1	28.0	30.8	55.6
	Tare plus dry soil	27.7	28.1	26.45	23.55	26.6	50.9
	Water W_w	5.3	5.6	4.65	4.45	4.2	4.7
	Tare	15.0	14.9	15.1	12.3	15.7	44.6
	Dry soil W_s	12.7	13.2	11.35	11.25	10.9	6.9
Water content	w	41.73	42.42	40.97	37.56	38.53	68.12
Number of blows		14	18	22	35	29	35



LL 39.56

PL 22.85

PI 16.71

Symbol from plasticity chart CL

PLASTIC LIMIT

Run No.		1	2	3	4	5	Natural Water Content
Tare No.		22	13	30	19	18	
Weight in grams	Tare plus wet soil	41.9	42.3	17.3	32.0	41.8	
	Tare plus dry soil	41.6	41.9	16.8	31.5	41.3	
	Water W_w	0.3	0.4	0.5	0.5	0.5	
	Tare	39.7	40.3	15.0	30.5	40.3	
	Dry soil W_s	1.9	1.6	1.8	1.0	1.0	
Water content	w	15.79	25.00	27.78	50.00	50.00	
Plastic limit							33.74

REMARKS Very Low Compressible Clayey Soil

TECHNICIAN Sackrider King COMPUTED BY [illegible] CHECKED BY Lewis

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HYDROMETER ANALYSIS

Date 10 OCT 1974

Project JCB DIRECTIVE No. 1-13

Boring No. STA. 11+50 GROUP #5

Sample or Specimen No.	E5-7	Classification	CL
Dish No. 5-004	Graduate No.	Hydrometer No.	A-1421-3
Dispersing agent used	CALGON	Quantity	60 mil.
Dispersing agent correction, C_d =	-3.8	Meniscus correction, C_m =	+0.5

Time	Elapsed Time min	Temp °C	Hydro. Reading (R')	Corrected Reading (R)	Temp Correction (m)	R + m	R' + C_m	Particle Diameter (D), mm	Percent Finer	
									Partial	Total
0841	0	—	—	—	—	—	—	—	—	—
0843	2	22°	52	48.7	+0.4	49.1	52.5	.0255	96.72	73.95
0845	4	22°	46	42.7	+0.4	43.1	46.5	.0191	84.90	64.91
0856	15	21°	39	35.7	+0.1	35.8	39.5	.0106	70.52	53.92
0911	30	21°	34.5	31.2	+0.1	31.3	35.0	.0078	61.66	47.14
0941	60	22°	32	28.7	+0.4	29.1	32.5	.0055	57.32	43.83
1041	120	21°	29	25.7	+0.1	25.8	29.5	.0040	50.82	38.86
1241	240	22°	25	21.7	+0.4	22.1	25.5	.0029	43.53	33.29

Weight in grams			
	Dish plus dry soil	375	
	Dish	325	
	Dry soil	50	W_o

Specific gravity of solids, G_s = 2.73

Corrected hydrometer reading (R) = hydrometer reading (R') + C_d + C_m

$D = K\sqrt{L/t}$

t = time min, L = effective length,

K = temperature, viscosity & G_s Factor

Hydrometer graduated in specific gravity

$$\text{Partial per cent finer} = \frac{G_s}{G_s - 1} \times \frac{100}{W_o} (R + m)\, a$$

Hydrometer graduated in grams per liter

$$\text{Partial per cent finer} = \frac{100}{W_o} (R + m)\, a$$

W_s = total oven-dry wt of sample used for combined analysis

W_o = oven-dry wt in grams of soil used for hydrometer analysis

W_1 = oven dry wt of sample retained on No. 200 or No. 10 sieve, whichever is applicable.

$$\text{Total per cent finer} = \text{partial per cent finer} \times \frac{W_s - W_1}{W_s}$$, and "a" is G_s factor

Remarks SOIL IS HIGHLY FROST SUSCEPTIBLE. Cu & Cc WERE UNATTAINABLE

Technician SACKRIDER NEAL Computed by KING Checked by OEST LEWIS

D—56,460—AG—Ft Belvoir

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SCBT 440.2A EA IS 1.2.8.1

Heavy Construction Branch, Dept. of Engr & Mil Science, USAES, Ft. Belvoir, Va.

DATA SHEET — COMPACTION & MOISTURE

Project JOB DIRECTIVE NO. 1-73 STA 11+50 Date 3 OCT 1974

Report Submitted By GROUP #5 NEAL, LEWIS, SACKRIDER, BEST & KING Sample No. E5-7

Number of Layers- 5 Number of Blows per Layer 55 Weight of Tamper 10 LB Height of Drop 18

Test No.	Units	5-1		5-4		5-7		5-10		5-13	
Wt. of Sample + Mold	Gm.	9095		9131		9036		8983		9229	
Wt. of Mold	Gm.	4235		4258		4195		4264		4266	
Wt. of Wet Sample	Gm.	4860		4873		4841		4719		4963	
Wet Unit Wt.	lb/cu ft	130.87		131.22		130.35		127.07		133.[illegible]	
Can No.		1	2	7	8	13	14	19	20	25	26
Wt. wet Sample + Can	gm	20.8	35.3	34.2	47.55	77.7	95.5	61.8	117.2	19.0	31.5
Wt. Dry Sample + Can	gm	19.8	32.2	31.5	44.4	71.7	86.9	56.4	103.4	17.9	29.2
Wt. Water	gm	1.0	3.1	2.7	5.15	6.0	8.6	5.4	13.8	1.1	2.3
Wt. Can	gm	15.4	15.7	15.9	15.0	44.0	40.3	30.5	39.7	12.3	14.9
Wt. of Dry Sample	gm	4.4	16.5	15.6	29.4	27.7	46.3	25.9	63.7	5.6	14.3
Water Content	Percent	22.7	18.9	17.3	17.5	21.7	19.2	20.8	21.7	19.6	16.1
Average Moisture Content	%	20.8		17.4		20.45		21.25		17.85	
Dry Unit Wt.	lb/cu ft	108.34		111.77		108.20		104.80		113.39	
SPEEDY		17.4		17.7		18.5		20.0		14.0	
DRY WT		111.47		111.49		110.0		105.89		117.21	

(19 of 49) (front)

Heavy Construction Branch, Dept. of Engr. & Mil. Science, Ft. Belvoir, Va.

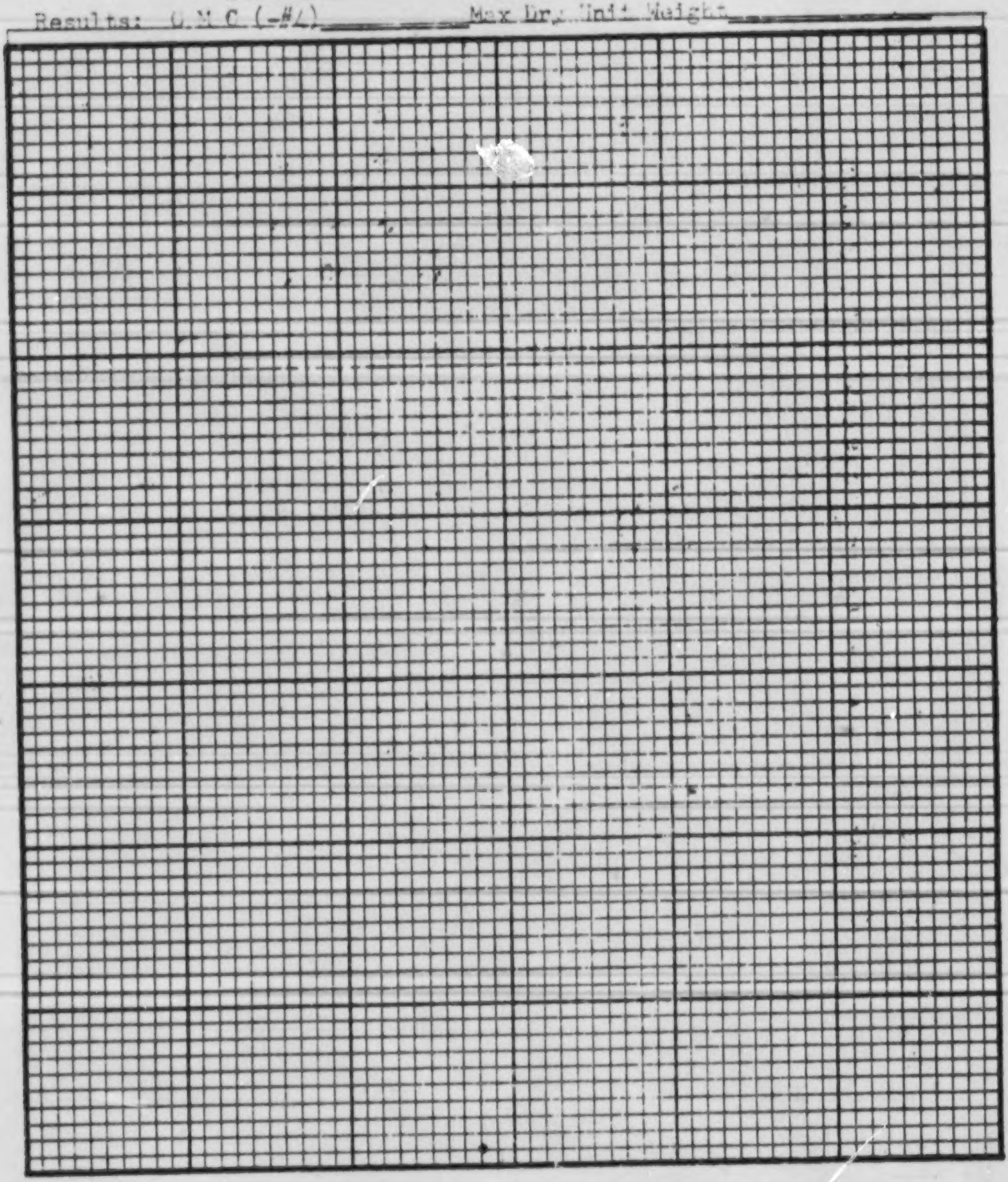
COMPACTION TEST FOR OPTIMUM MOISTURE CONTENT

Project_______________________________Date______________________

Report Submitted by____

Test Procedure__________________________Sample No.______________

Results: O.M.C (-#4)____________Max Dry Unit Weight______________



(19 of 49) (back)

20,000—Ft Belvoir

Heavy Construction Branch, Dept. of Engr & Mil Science, USAES, Ft. Belvoir, Va.

DATA SHEET — COMPACTION & MOISTURE

Project JCB DIRECTIVE NO. 1-73 STA 11+50 Date 3 OCT 1974

Report Submitted By GROUP #5 NEAL, LEWIS, SACKRIDER OEST, & KING Sample No. E5-7

Number of Layers- 5 Number of Blows per Layer 55 Weight of Tamper 10 LB Height of Drop 18"

Test No.	Units	5-14		5-15		5-16					
Wt. of Sample + Mold	GR.	8937		8986		9084					
Wt. of Mold	GR.	4141		4270		4263					
Wt. of Wet Sample	GR.	4796		4716		4821					
Wet Unit Wt.	lb/cu ft	129.14		126.46		129.82					
Can No.		15	20	27	30	21	12				
Wt. Wet Sample + Can	gm	81.2	71.3	66.3	40.4	69.0	90.4				
Wt. Dry Sample + Can	gm	76.2	67.4	63.0	37.7	65.3	84.1				
Wt. Water	gm	5.0	3.9	3.3	2.7	3.7	6.3				
Wt. Can	gm	49.0	39.7	39.4	15.0	39.5	39.7				
Wt. of Dry Sample	gm	27.2	27.7	23.6	22.1	25.8	44.4				
Water Content	Percent	18.38	14.08	14.00	14.10	14.38	14.19				
Average Moisture Content	%	16.23		14.05		14.27					
Dry Unit Wt.	lb/cu ft	111.11		118.88		113.67					
SPEEDY		12.5		12.3		13.0					
DRY WT.		114.79		113.08		114.8					

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Heavy Construction Branch, Dept. of Engr. & Mil. Science, Ft. Belvoir, Va.

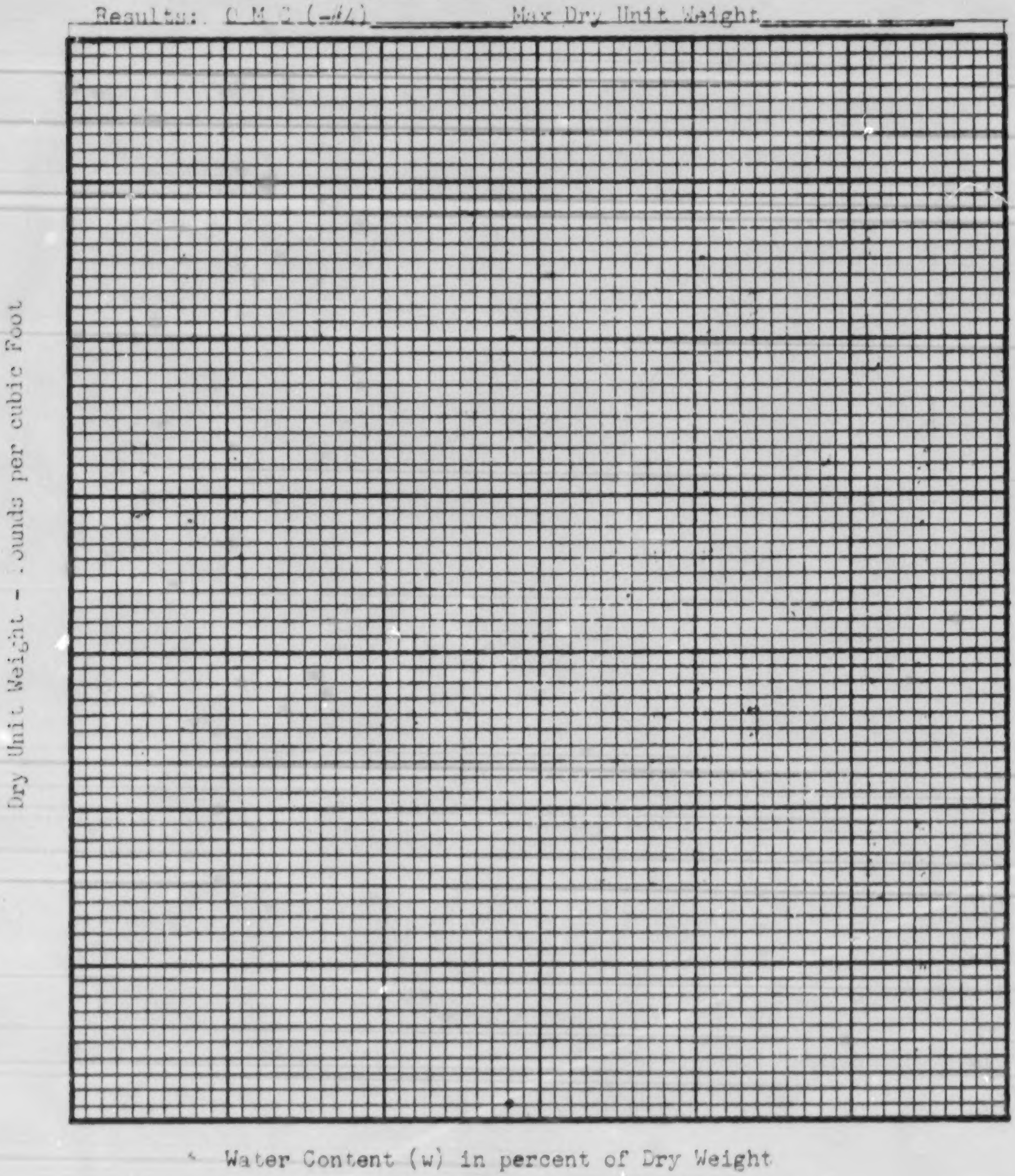
COMPACTION TEST FOR OPTIMUM MOISTURE CONTENT

Project________________________________Date____________________

Report Submitted by____

Test Procedure__________________________Sample No.______________

Results: O M C (-#4)__________Max Dry Unit Weight______________



20,090--Ft Belvoir

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Heavy Construction Branch, Dept. of Engr & Mil Science, USAES, Ft. Belvoir, Va.

DATA SHEET — COMPACTION & MOISTURE

Project JCS DIRECTIVE NO. 1-73 STA 11+50 Date 3 OCT 1974

Report Submitted By GROUP #5 NEAL, LEWIS, SACKRIDER, DEST, & KING Sample No. E5-7

Number of Layers- 5 Number of Blows per Layer 26 Weight of Tamper 10 LB Height of Drop 18"

Test No.	Units	5-2		5-5		5-8		5-11		5-17	
Wt. of Sample + Mold	GR.	8951		8960		9101		8984		9027	
Wt. of Mold	GR.	4269		4269		4299		4255		4293	
Wt. of Wet Sample	GR.	4682		4691		4802		4729		4734	
Wet Unit Wt.	lb/cu ft	126.07		126.31		129.30		127.34		127.47	
Can No.		3	4	9	10	15	16	21	22	16-Δ	4-Δ
Wt. wet Sample + Can	gm	32.9	40.9	31.4	80.1	67.5	97.9	80.6	114.1	107.8	77.9
Wt. Dry Sample + Can	gm	30.0	37.0	28.8	73.85	63.3	88.0	73.9	100.0	97.7	72.3
Wt. Water	gm	2.9	3.9	2.6	6.25	4.2	9.4	6.7	14.1	10.1	5.6
Wt. Can	gm	13.7	15.35	15.4	42.0	47.0	44.0	39.5	39.9	44.0	39.3
Wt. of Dry Sample	gm	16.3	21.65	13.4	31.85	14.3	44.0	34.4	60.1	53.7	33.0
Water Content	Percent	17.79	18.0	19.4	19.6	29.37	21.36	19.48	23.46	18.8	16.77
Average Moisture Content	%	17.89		19.50		25.36		21.47		17.89	
Dry Unit Wt.	lb/cu ft	106.93		105.70		103.14		104.83		108.13	
		107.38		107.31		109.11		106.11			
SPEEDY		17.4		17.7		18.5		20.0		14.0	

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Heavy Construction Branch, Dept. of Engr. & Mil. Science, Ft. Belvoir, Va.

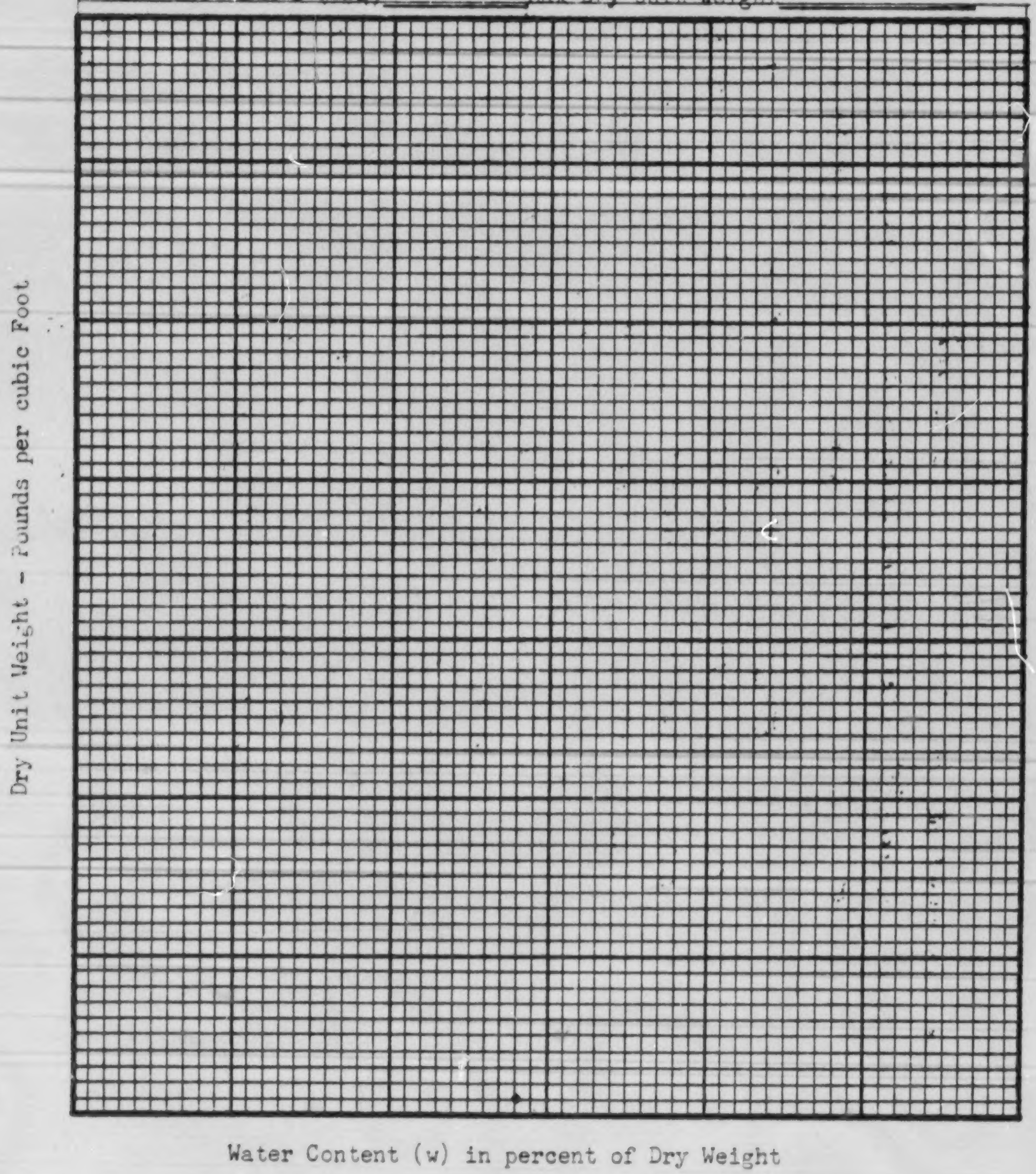
COMPACTION TEST FOR OPTIMUM MOISTURE CONTENT

Project____________________________________Date__________________________

Report Submitted by____

Test Procedure____________________________Sample No.____________________

Results: O M C (-#4)____________Max Dry Unit Weight________________



Heavy Construction Branch, Dept. of Engr & Mil Science, USAES, Ft. Belvoir, Va.

DATA SHEET — COMPACTION & MOISTURE

Project JOB DIRECTIVE NO 1-73 STA 11+50 Date 3 OCT 1974

Report Submitted By GROUP #5 NEAL, LEWIS, SACKRIDER, OEST, & KING Sample No. E5-7

Number of Layers- 5 Number of Blows per Layer 12 Weight of Tamper 10Lb Height of Drop 18"

Test No.	Units	5-3		5-6		5-9		5-12		5-18	
Wt. of Sample + Mold	GR.	8631		8549		8721		8880		8730	
Wt. of Mold	GM.	4414		4254		4264		4282		4316	
Wt. of Wet Sample	GM.	4217		4295		4457		4598		4414	
Wet Unit Wt.	lb/cu ft	113.55		115.65		120.01		123.81		118.86	
Can No.		5	6	11	12-A	17	18	23	24	29	19-A
Wt. wet Sample + Can	gm	38.0	43.6	70.3	100.8	93.1	124.5	124.4	93.2	132.5	112.5
Wt. Dry Sample + Can	gm	34.4	39.2	65.4	91.5	84.0	111.2	109.0	83.9	113.6	97.7
Wt. Water	gm	3.6	4.4	4.9	9.3	9.1	13.3	15.4	9.3	18.9	14.8
Wt. Can	gm	15.35	15.45	30.8	39.7	39.3	40.3	39.9	40.1	39.2	39.2
Wt. of Dry Sample	gm	19.05	23.75	34.6	51.8	44.7	70.9	69.1	43.8	74.4	58.5
Water Content	Percent	18.90	18.55	14.16	17.95	20.36	18.76	22.29	21.23	25.4	25.29
Average Moisture Content %		18.72		16.05		19.56		21.76		25.34	
Dry Unit Wt.	lb/cu ft	95.65		99.67		100.38		101.68		94.83	
SPEEDY		17.4		17.7		18.5		20.0		14.0	

(22 of 49)(front)

Heavy Construction Branch, Dept. of Engr. & Mil. Science, Ft. Belvoir, Va.

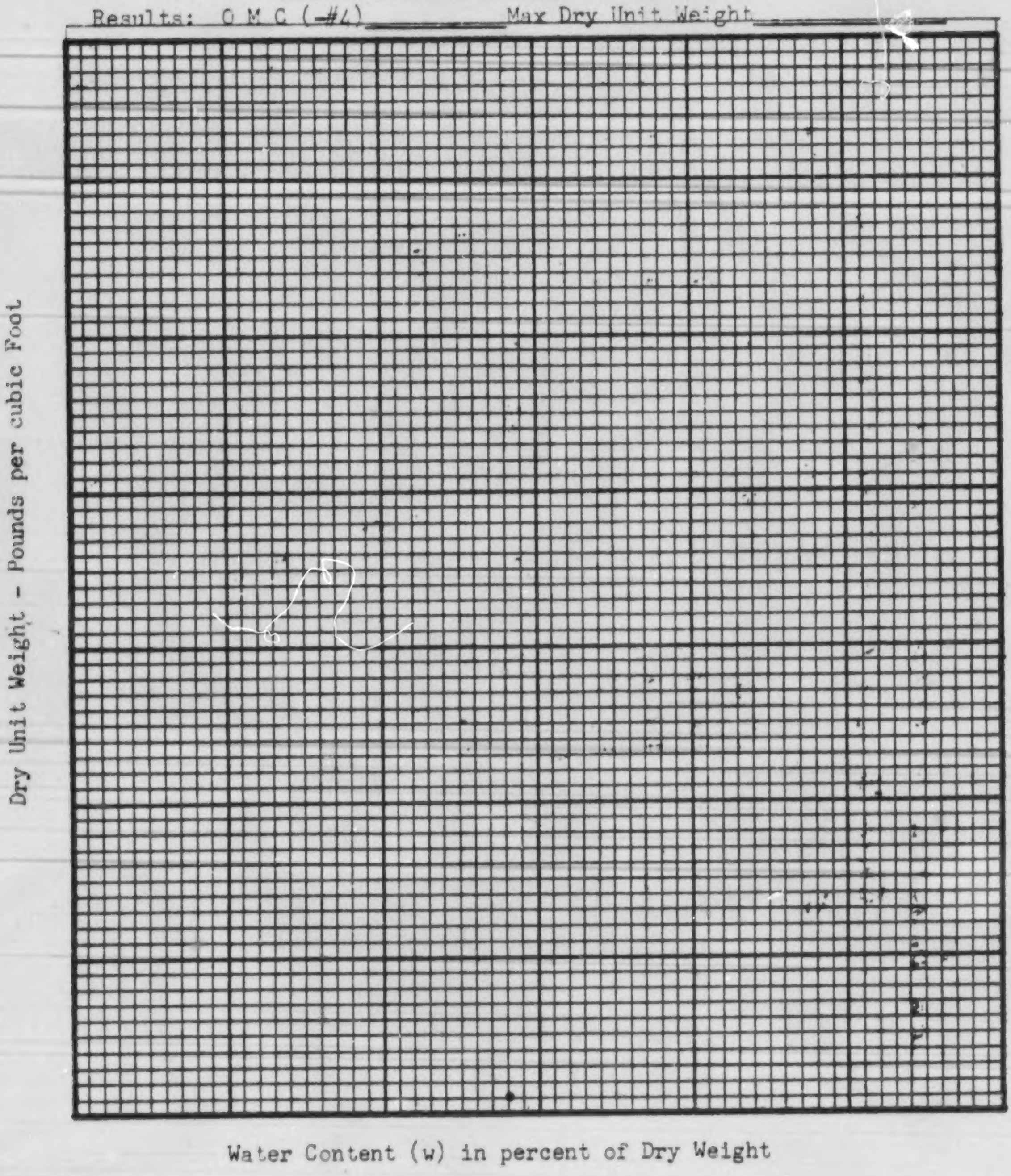
COMPACTION TEST FOR OPTIMUM MOISTURE CONTENT

Project____________________________ Date____________________

Report Submitted by____

Test Procedure_______________________ Sample No.______________

Results: O M C (-#4)________ Max Dry Unit Weight____________



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CALIFORNIA BEARING RATIO

PENE. inches	TIME minutes	STAND. LOAD p.s.i.	Gage Readings 4	5	6	Test Load Lbs.			Test Load Psi			Corrected Test Load PSI			C B R in %		
			55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows
0.025	0.5		.0002	.0007	.0002	20	70	20	6.7	23.3	6.7						
0.050	1.0		.0007	.0016	.00045	70	160	45	23.3	53.3	15.0						
0.075	1.5		.00135	.0025	.0006	135	250	60	45.0	83.3	20.0						
0.100	2.0	1000	.0020	.0031	.00075	200	310	75	66.7	103.3	25.0	82.5	112.0	26.0	8.25	11.2	26.0
0.125	2.5		.00265	.0037	.0009	265	370	90	88.3	123.3	30.0						
0.150	3.0		.00335	.00425	.0010	335	425	100	111.7	141.7	33.3						
0.175	3.5		.00410	.0046	.0011	410	460	110	136.7	153.3	36.7						
0.200	4.0	1500	.0047	.0050	.00115	470	500	115	156.7	166.7	38.3	176.25	172.0	41.0	11.75	11.4	2.70
0.250	5.0		.0060	.00585	.00135	600	585	135	200.0	195.0	45.0						
0.300	6.0		.0072	.0066	.00150	720	660	150	240.0	220.0	50.0						
0.350	7.0		.0084	.0074	.00165	840	740	165	280.0	246.7	55.0						
0.400	8.0		.0095	.0081	.00190	950	810	190	316.7	270.0	63.3						
0.450	9.0		.0106	.0086	.00195	1060	860	195	353.3	286.7	65.0						
0.500	10.0		.0118	.0093	.00210	1180	930	210	393.3	310.0	70.0						

SWELL DATA

Date	Time in Days, Hours or Minutes			Gage Reading			Swell in Inches			Swell in %					
	55/B	26/B	12/B	55/B	26/B	12/B	55/B	26/B	12/B	55/B	26/B	12/B			
7 OCT 1974	4 DAYS	4 DAYS	4 DAYS	31.0	77.0	69.0	.031	.077	.069	.62	1.54	1.38			

OP-3 STA 1+50

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Ft Belvoir

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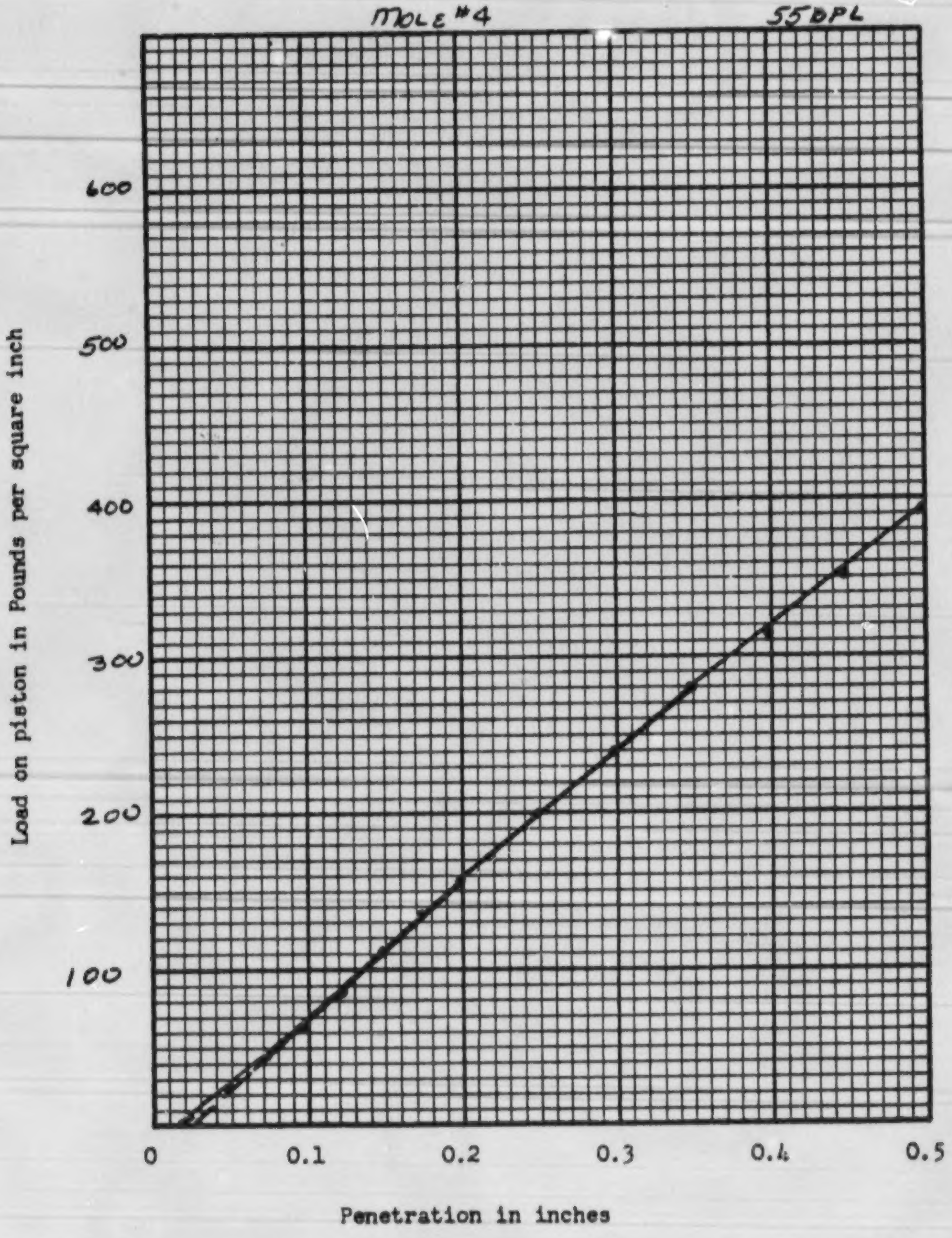
Heavy Construction Branch, Dept. of Engr. & Mil. Science

CBR VERIFICATION GRAPH

GR. #5
STA 11+50

Corrected Load @ 0.1 = 82.5 PSI

Corrected Load @ 0.2 = 176.25 PSI



(24 of 49)

2- -23,830—Ft Belvoir

HCBT 440.7A EA IS 1.2.8.1

Heavy Construction Branch, Dept. of Engr. & Mil. Science

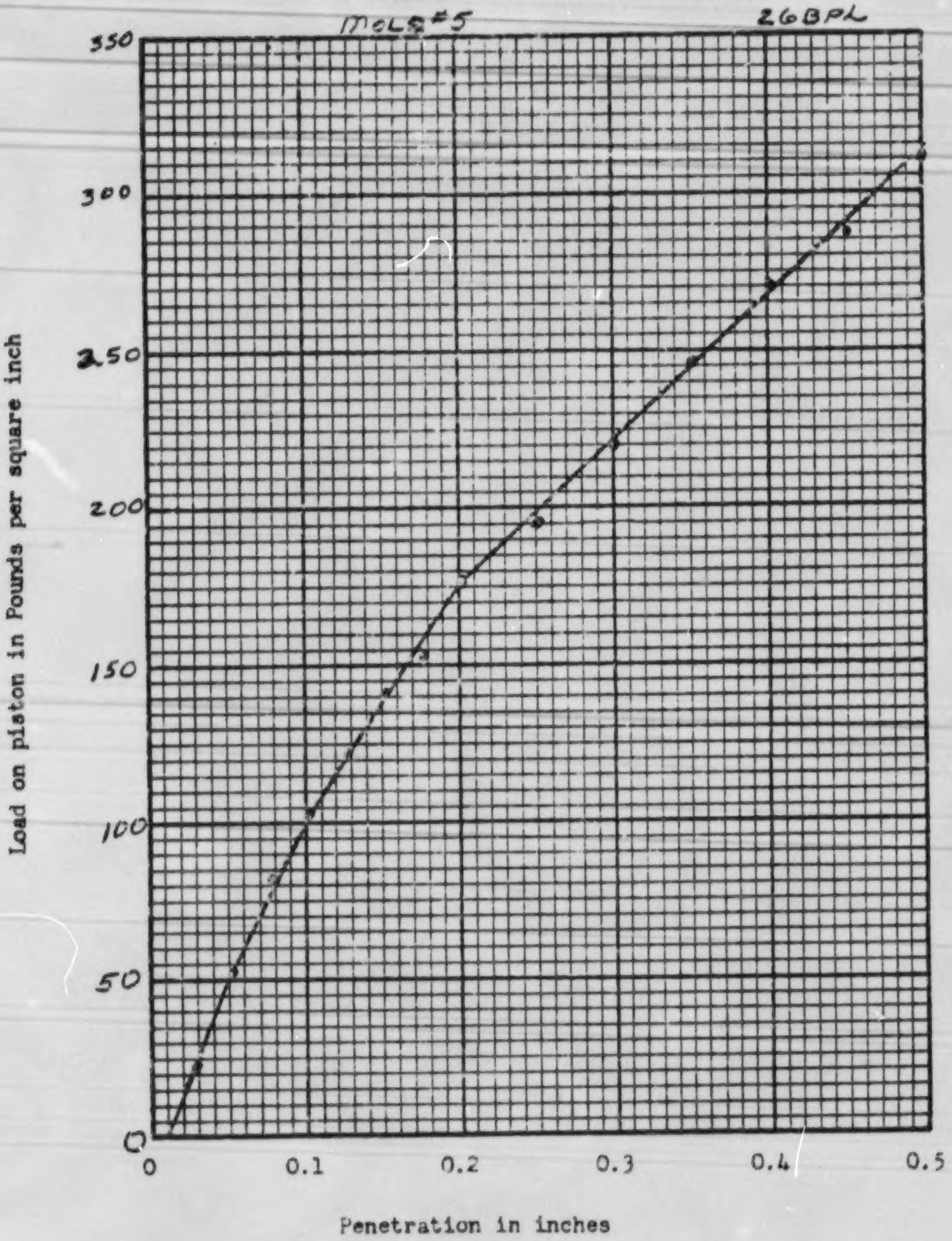
6P#5

CBR VERIFICATION GRAPH

STA 11+50

Corrected Load @ 0.1 = 112.0 PSI

Corrected Load @ 0.2 = 172.0 PSI



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Heavy Construction Branch, Dept. of Engr. & Mil. Science

GP#5

CBR VERIFICATION GRAPH

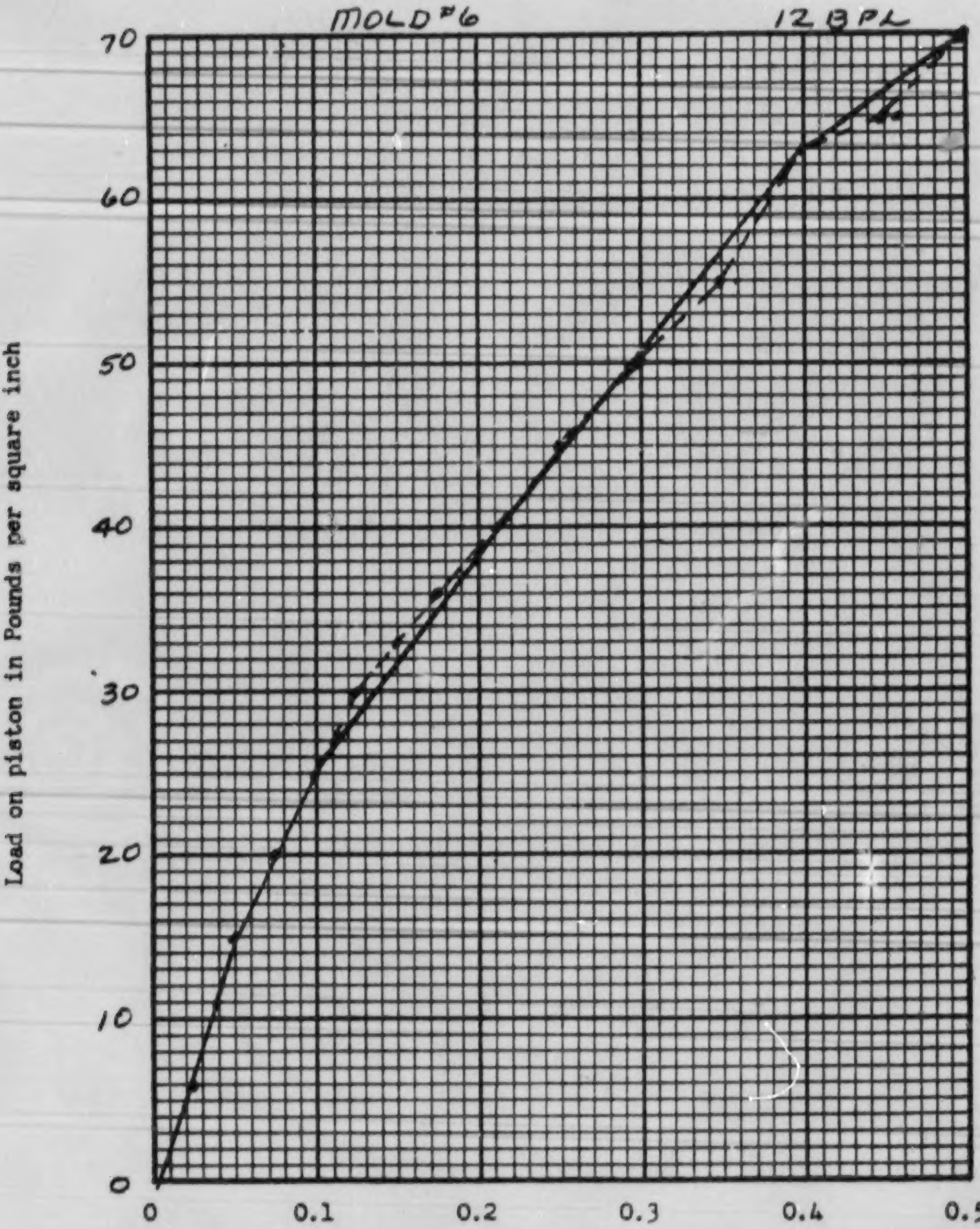
STA 11+50

Corrected Load @ 0.1 = 26.0 PSI

Corrected Load @ 0.2 = 41.0 PSI

MOLD #6

12 BPL



Penetration in inches

(26 of 49)

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CALIFORNIA BEARING RATIO

PENE. inches	TIME minutes	STAND. LOAD p.s.i.	Gage Readings 7	8	9	Test Load Lbs.			Test Load Psi			Corrected Test Load PSI			C B R in %		
			55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows
0.025	0.5		.0003	.0006	.0002	30	60	20	10.0	20.0	6.7						
0.050	1.0		.00067	.0014	.0009	67	140	40	22.3	46.7	13.3						
0.075	1.5		.00105	.0021	.00065	105	210	65	35.0	70.0	21.7						
0.100	2.0	1000	.0015	.0028	.00085	150	280	85	50.0	93.3	28.3	75.0	100.0	30.0	7.5	10.0	3.0
0.125	2.5		.00195	.0033	.0010	195	330	100	65.0	110.0	33.3						
0.150	3.0		.00231	.0037	.0012	231	370	120	77.0	123.3	40.0						
0.175	3.5		.0027	.0042	.0013	270	420	130	90.0	140.0	43.3						
0.200	4.0	1500	.00315	.00465	.0015	315	465	150	105.0	155.0	50.0	125.0	157.0	49.5	8.3	10.4	3.3
0.250	5.0		.00385	.0052	.00175	385	520	175	128.3	173.3	58.3						
.300	6.0		.0047	.00615	.00205	470	615	205	156.7	205.0	68.3						
.350	7.0		.0055	.0068	.0022	550	680	220	183.3	226.7	73.3						
.400	8.0		[illegible]	.0077	.00255	625	770	255	[illegible]	256.7	85.0						
.450	9.0		.00715	.0082	.00275	715	820	275	238.3	273.3	91.7						
.500	10.0		.00795	.0088	.0030	795	880	300	265.0	293.3	100.0						

SWELL DATA

Date	Time Duration, Hours or Minutes														
	/B														
7 OCT 1974	4 DAYS	4 DAYS	4 DAYS	29.0	28.0	57.0	.029	.028	.057	.58	.56	1.14			

IS 415 Ft Belvoir

STA. 1145
G/--5

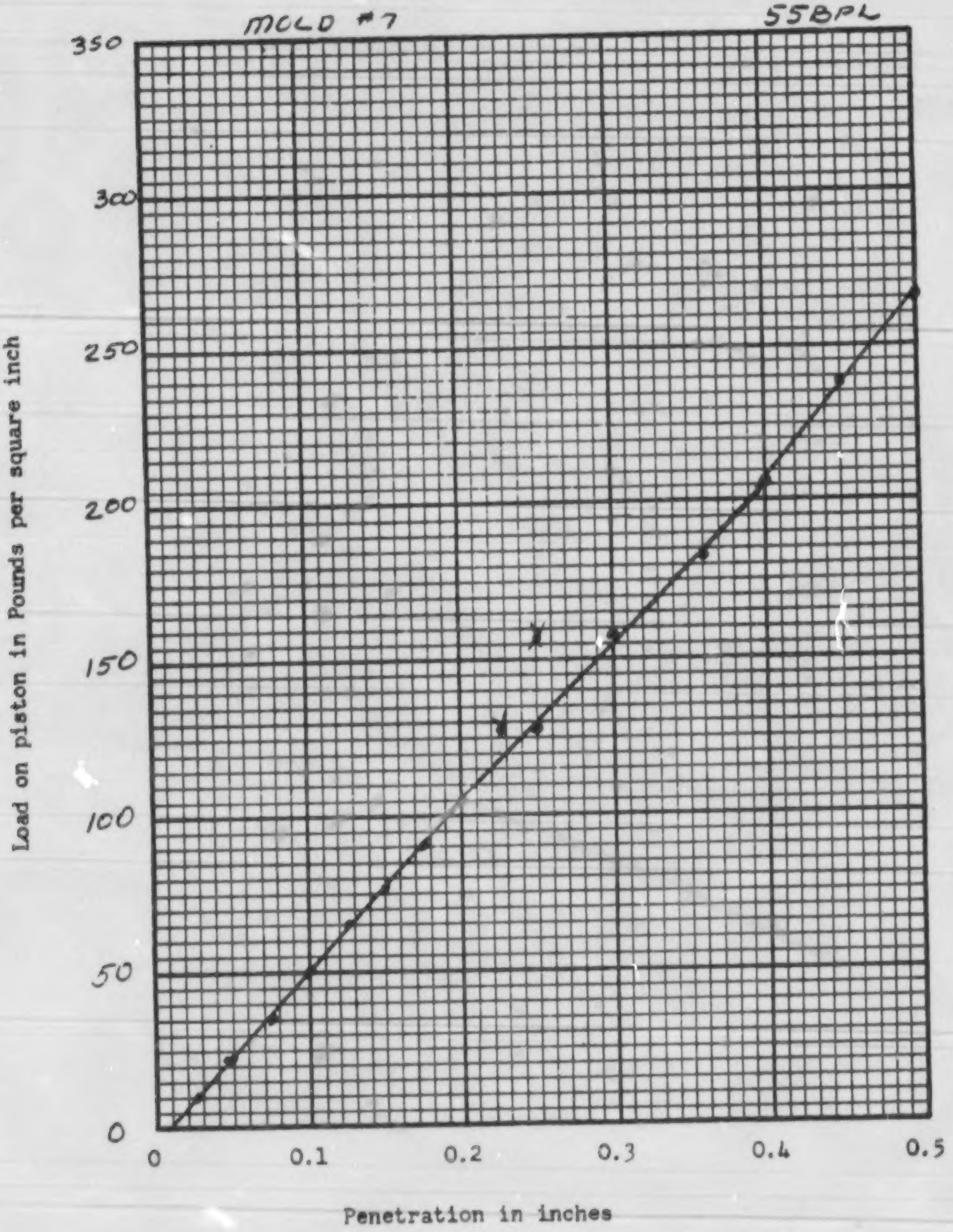
Heavy Construction Branch, Dept. of Engr. & Mil. Science Gr#5

CBR VERIFICATION GRAPH

STA 11+50

Corrected Load @ 0.1 = 75.0 PSI

Corrected Load @ 0.2 = 125.0 PSI



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SCPT 440.2A EA IS 1.2.8.1

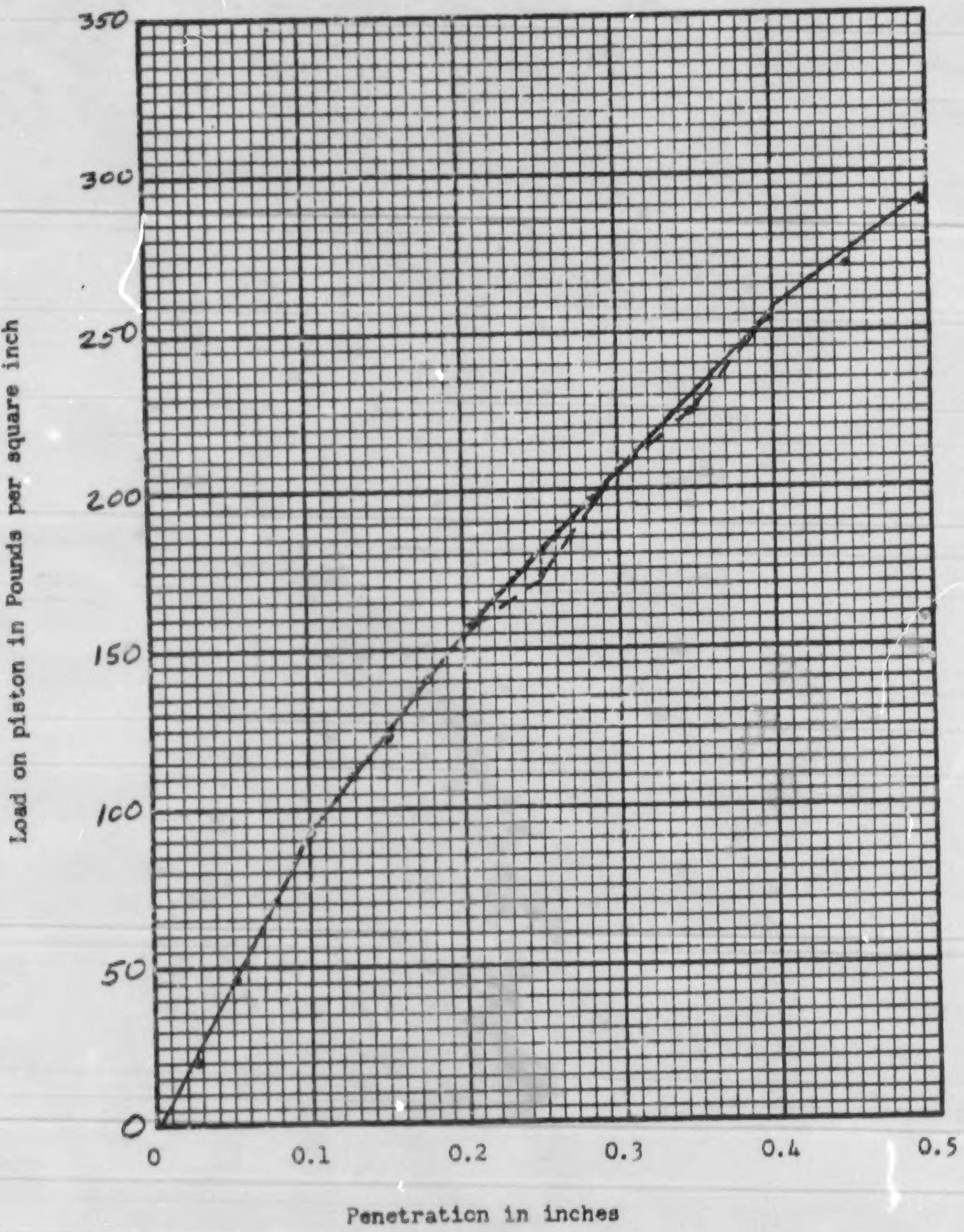
Heavy Construction Branch, Dept. of Engr. & Mil. Science

CBR VERIFICATION GRAPH

GP#5
STA 11+50

Corrected Load @ 0.1 = 100.0 PSI

Corrected Load @ 0.2 = 157.0 PSI



(29 of 49)

SCBT 440.2A EA IS 1.2.8.1

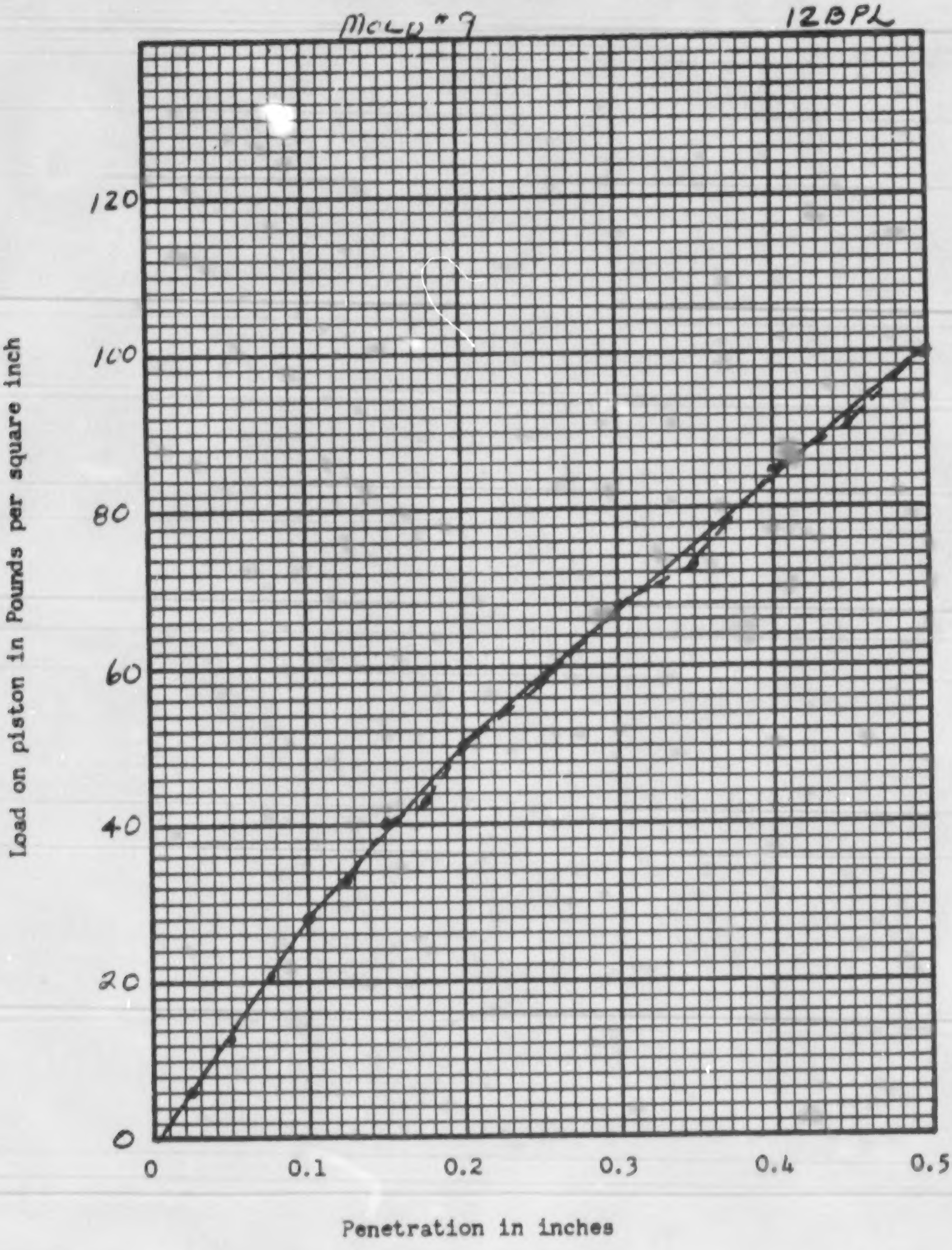
Heavy Construction Branch, Dept. of Engr. & Mil. Science

CBR VERIFICATION GRAPH

GP#5
STA 1+60

Corrected Load @ 0.1 = 30.0 PSI

Corrected Load @ 0.2 = 49.5 PSI



2- -25,530—Ft Belvoir

CALIFORNIA BEARING RATIO

PENE. inches	TIME minutes	STAND. LOAD p.s.i.	Gage Readings 10	11	12	Test Load Lbs.			Test Load Psi			Corrected Test Load PSI			C B R in %		
			55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows
0.025	0.5		.00005	.0002	.0002	5	20	20	1.7	6.7	6.7						
0.050	1.0		.00015	.0004	.00055	15	40	55	5.0	13.3	18.3						
0.075	1.5		.0002	.0005	.00085	20	50	85	6.7	16.7	28.3						
0.100	2.0	1000	.0004	.0007	.0011	40	70	110	13.3	23.3	36.7	27.0	30.0	40.0	2.7	3.0	4.0
0.125	2.5		.00055	.00075	.00125	55	95	135	18.3	31.6	45.0						
0.150	3.0		.0007	.0012	.00155	70	120	155	23.3	40.0	51.7						
0.175	3.5		.0008	.00135	.00175	80	135	175	26.7	45.0	58.3						
0.200	4.0	1500	.0009	.0016	.0020	90	160	200	30.0	53.3	66.7	40.5	57.5	68.0	2.7	3.8	4.5
[illegible]	5.0		.0012	.00195	.0024	120	195	240	40.0	65.0	80.0						
[illegible]	6.0		.0014	.0024	.0028	140	240	280	46.7	80.0	93.3						
0.[illegible]	7.0		.00165	.0027	.0031	165	270	310	55.0	90.0	103.3						
[illegible]	8.0		.00195	.0031	.0034	195	310	320	65.0	103.3	119.3						
[illegible]	9.0		.0022	.0034	.00375	220	345	375	73.3	115.0	125.0						
[illegible]	10.0		.0024	.0040	.00415	242	400	415	80.7	133.3	138.3						

SWELL DATA

Date	Time In Days, Hours or Minutes			Gage Reading			Swell In Inches			Swell in %					
	55/B	26/B	12/B	55/B	26/B	12/B	55/B	26/B	12/B	55/B	26/B	12/B			
7 OCT 1974	4 DAYS	4 DAYS	4 DAYS	44.0	33.0	34.0	.044	.033	.034	.88	.66	.68			

GP#6
STA
11+50

[illegible] Ft Belvoir

SCBT 440.2A EA IS 1.2.8.1

Heavy Construction Branch, Dept. of Engr. & Mil. Science GP# 5 215

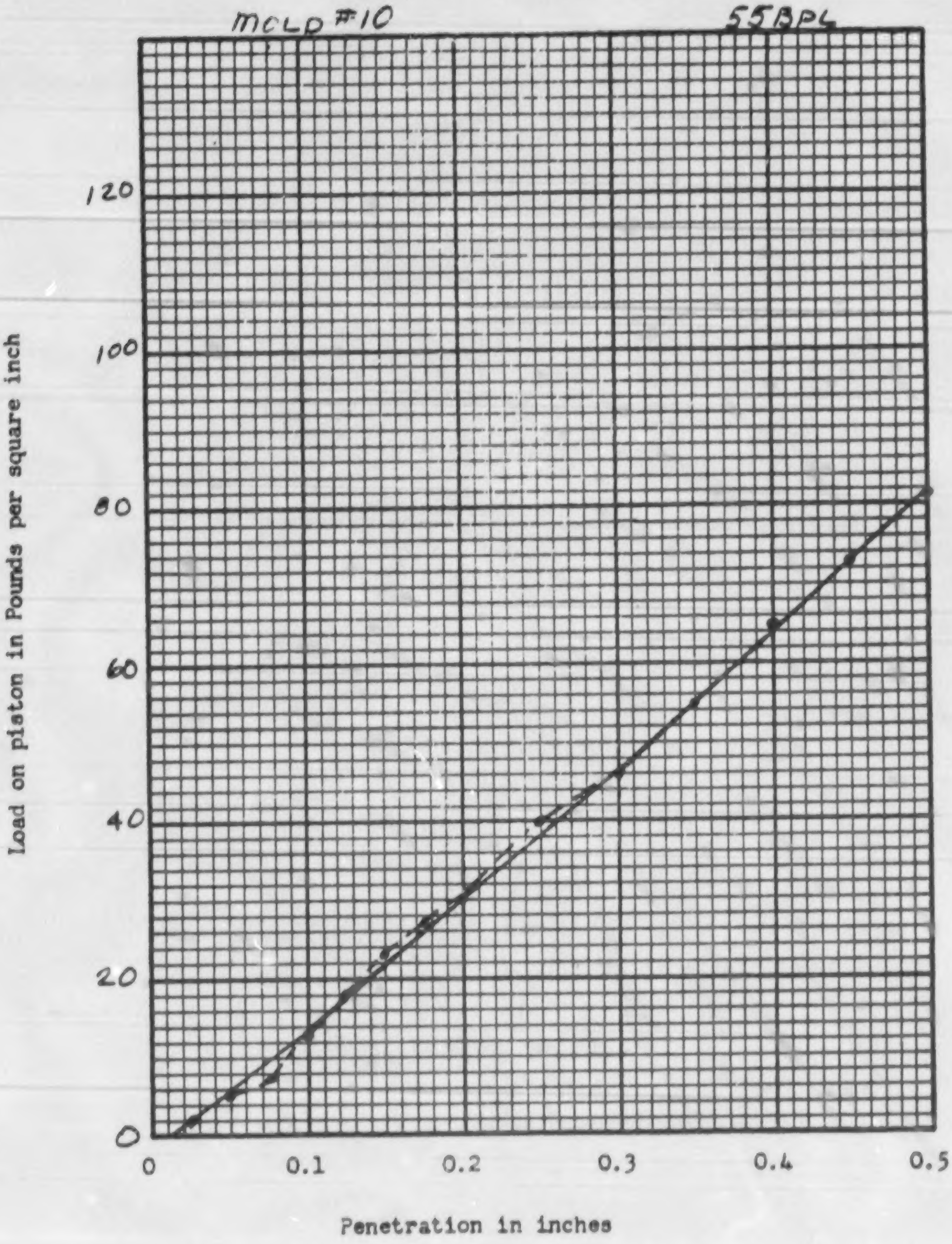
CBR VERIFICATION GRAPH

STA. 11+50

Corrected Load @ 0.1 - 27.0 PSI

Corrected Load @ 0.2 - 40.6 PSI

MOLD #10 55BPL



3- -26,830—Ft Belvoir

[illegible] EA FS 1.2.8.1

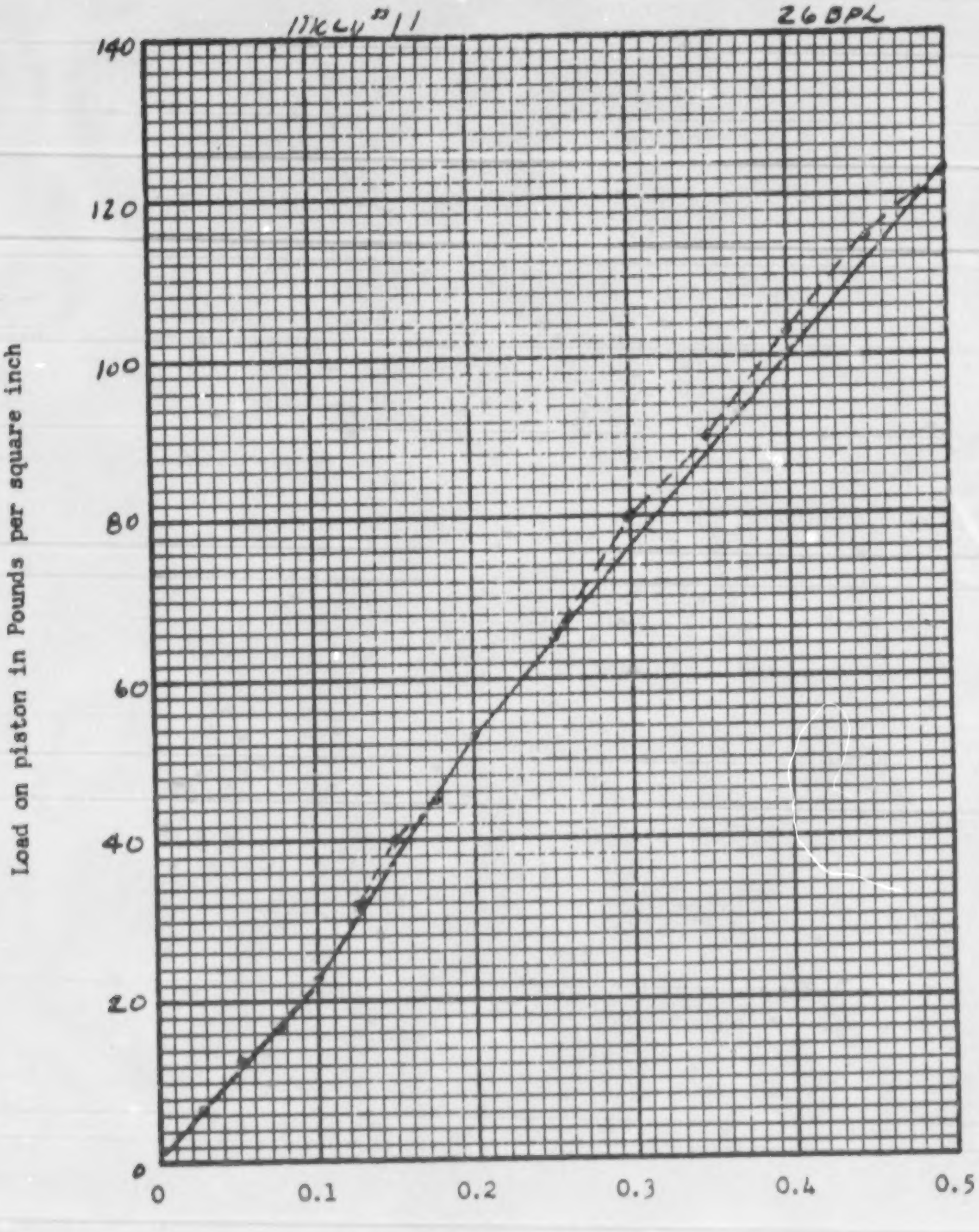
Heavy Construction Branch, Dept. of Engr. & Mil. Science

CBR VERIFICATION GRAPH

GP#5
STD
11+50

Corrected load @ 0.1 = 82.0 PSI

Corrected load @ 0.2 = 125.0 PSI



Heavy Construction Branch, Dept. of Engr. & Mil. Science GP#5 STA 11+50 217

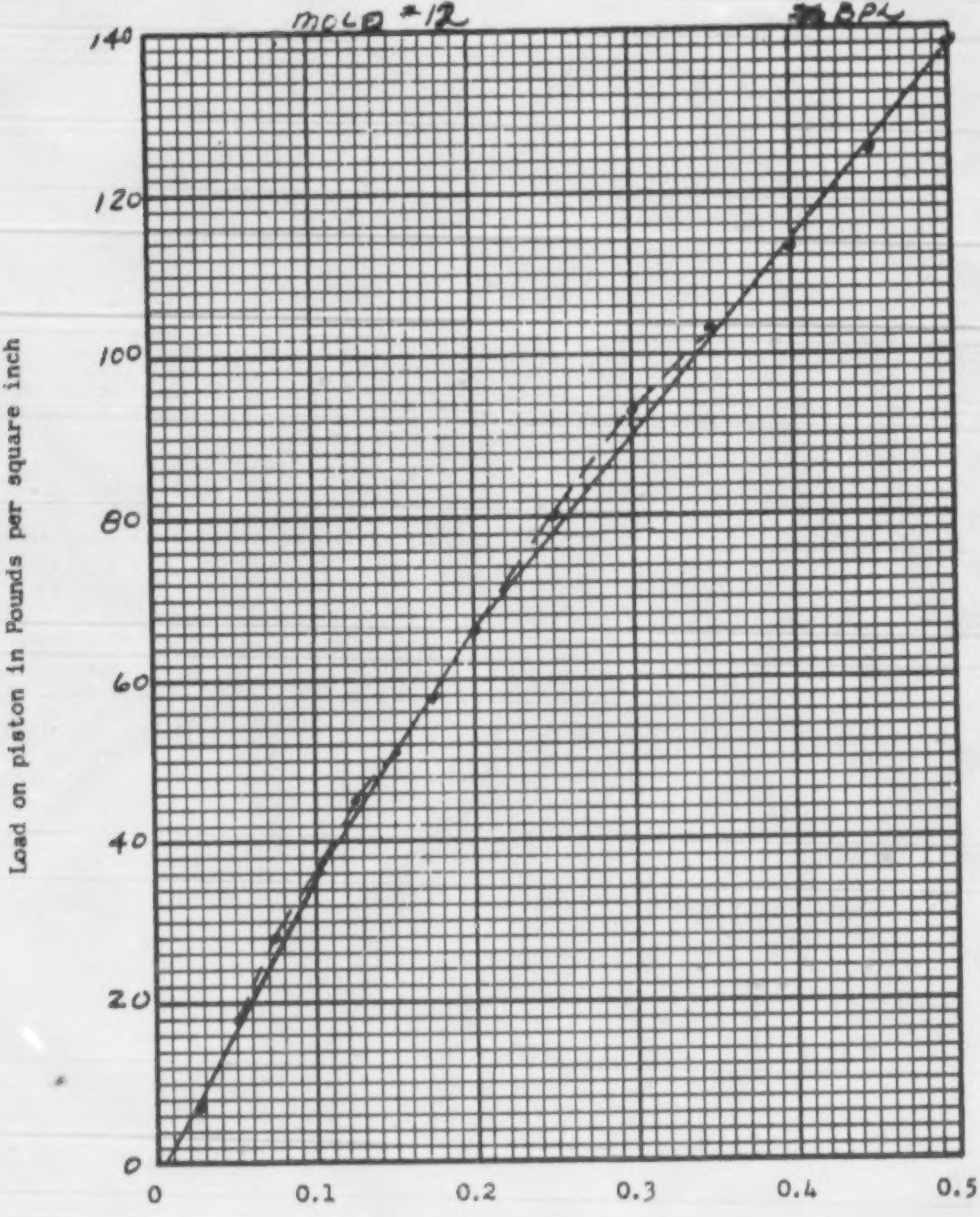
CBR VERIFICATION GRAPH

Corrected Load @ 0.1 = 9.1 PSI

Corrected Load @ 0.2 = 16.8 PSI

MOLD #12

12 BPL



(34 of 49)

3 -28,830—Ft Belvoir

218

CALIFORNIA BEARING RATIO

PENE. inches	TIME minutes	STAND. LOAD p.s.i.	Gage Readings 13	17	18	Test Load Lbs.			Test Load Psi			Corrected Test Load PSI			CBR in %		
			55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows
0.025	0.5		.0009	.0006	.00005	90	60	5	30	20	1.7						
0.050	1.0		.00195	.0011	.00008	195	110	8	65	36.7	2.7						
0.075	1.5		.00315	.0015	.00015	315	150	15	105	50.0	5.0						
0.100	2.0	1000	.0045	.0020	.0002	450	200	20	150	66.7	6.7	165.0	82.0	9.1	16.5	8.25	.91
0.125	2.5		.0056	.0025	.00028	560	250	28	186.7	83.3	9.3						
0.150	3.0		.0069	.0028	.00035	690	280	35	230	93.3	11.7						
0.175	3.5		.0081	.0032	.0004	810	320	40	270	106.7	13.3						
0.200	4.0	1500	.0093	.0035	.00045	930	350	45	310	116.7	15.0	325.0	125.0	16.8	21.7	18.3	1.12
0.250	5.0		.01125	.0041	.00055	1125	410	55	375	136.7	18.3						
0.300	6.0		.0132	.0048	.00065	1320	480	65	440	160.0	21.7						
0.350	7.0		.0149	.0054	.00075	1490	540	75	496.7	180.0	25.0						
0.400	8.0		.0169	.0061	.0009	1690	610	90	563.4	203.3	30.0						
0.450	9.0		.0184	.0067	.00095	1840	670	95	613.4	223.3	31.7						
0.500	10.0		.0200	.0072	.00105	2000	720	105	666.7	240.0	35.0						

SWELL DATA

Date	Time in Days, Hours or Minutes 13	17	18	Gage Reading			Swell in Inches			Swell in %					
	55/B	26/B	12/B	55/B	26/B	12/B	55/B	26/B	12/B	55/B	26/B	12/B			
7 OCT	4 DAY			11.0			.011			.22					
8 OCT		4 DAY	4 DAY		86.5	117.0		.0865	.117		1.13	2.34			
1974															

GP# 5
STA
11+50

21

Heavy Construction Branch, Dept. of Engr. & Mil. Science

6P#5

CBR VERIFICATION GRAPH

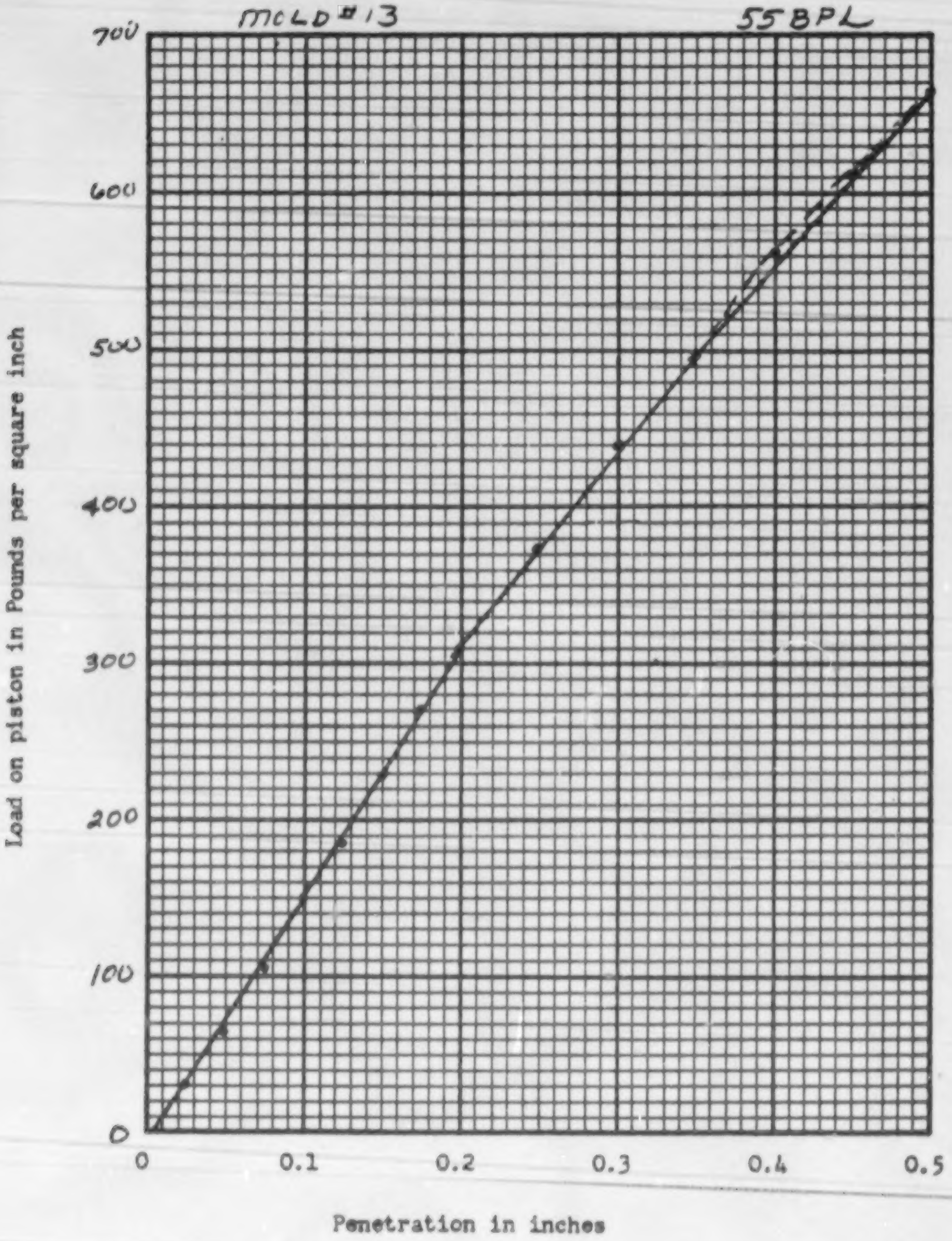
STD
11+50

Corrected Load @ 0.1 = 165.0 PSI

Corrected Load @ 0.2 = 325.0 PSI

MOLD #13

55BPL



3- -55 530—Ft Belvoir

SCBT 440.2A EA IS 1.2.8.1

Heavy Construction Branch, Dept. of Engr. & Mil. Science

CBR VERIFICATION GRAPH

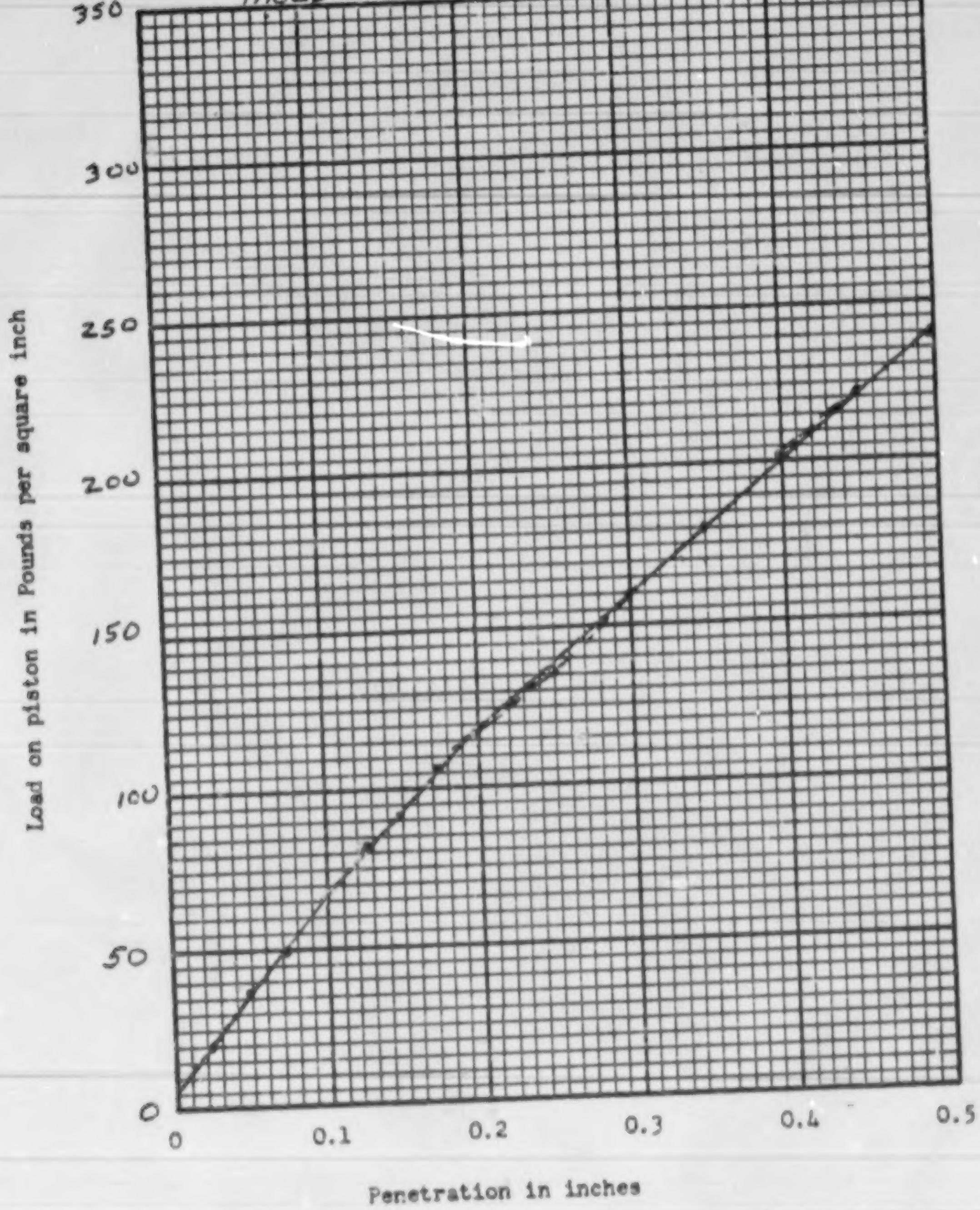
GP#5
STA 11+80

Corrected Load @ 0.1 = 82.0 PSI

Corrected Load @ 0.2 = 125.0 PSI

MOLD = 17

26 BDL



3. 28.530—Ft Belvoir

SCBT 440.2A EA IS 1.2.8.1

221

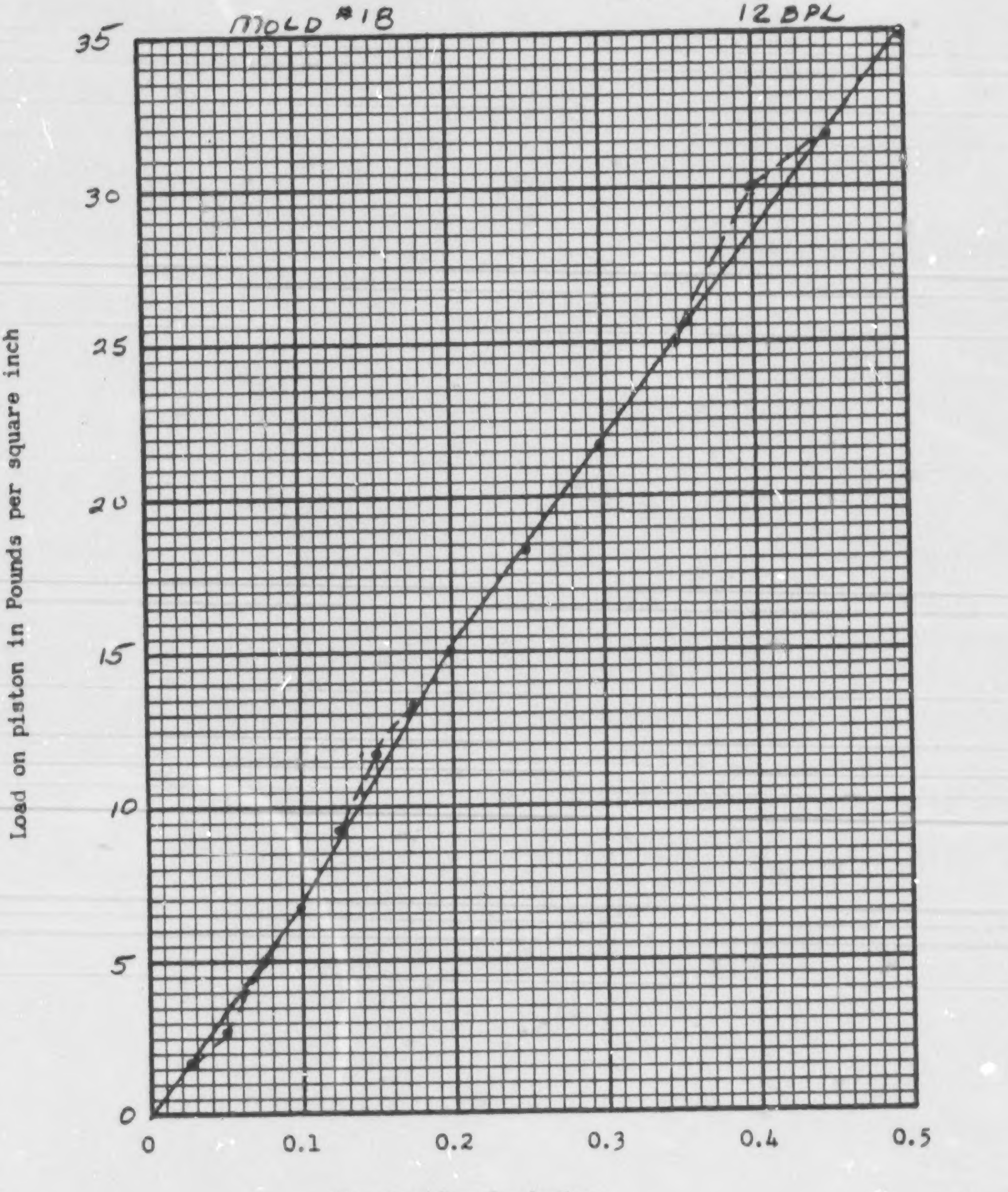
Heavy Construction Branch, Dept. of Engr. & Mil. Science

CBR VERIFICATION GRAPH

GP=5
STD 11+50

Corrected Load @ 0.1 = 9.1 PSI

Corrected Load @ 0.2 = 16.8 PSI



(38 of 49)

2 -25,830—Ft Belvoir

SCBT 440.2A EA IS 1.2.8.1

CALIFORNIA BEARING RATIO

PENE. inches	TIME minutes	STAND. LOAD p.s.i.	Gage Readings 14			Test Load 14 lbs.			Test Load Psi			Corrected Test Load PSI			C B R in %		
			55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows
0.025	0.5		.0005			50			16.7								
0.050	1.0		.0012			120			40.0								
0.075	1.5		.00185			185			61.7								
0.100	2.0	1000	.0025			250			83.3			87.0			8.7		
0.125	2.5		.0030			300			100.0								
0.150	3.0		.00345			345			115.0								
0.175	3.5		.0040			400			133.3								
0.200	4.0	1500	.0044			440			146.7			150.0			10.0		
0.250	5.0		.0052			520			173.3								
0.300	6.0		.0060			600			200.0								
0.350	7.0		.0067			670			233.3								
0.400	8.0		.00765			765			255.0								
0.450	9.0		.0085			850			283.3								
0.500	10.0		.0094			940			313.3								

SWELL DATA

Date	Time in Days, Hours or Minutes 19			Gage Reading			Swell in Inches			Swell in %					
	55/B	26/B	12/B	55/B	26/B	12/B	55/B	26/B	12/B	55/B	26/B	12/B			
8 OCT 1974	4 DAYS			106.0			.106			2.12					

GR #5
STA 11+50

SCBT 440.2A EA IS 1.2.8.1

Heavy Construction Branch, Dept. of Engr. & Mil. Science

CBR VERIFICATION GRAPH

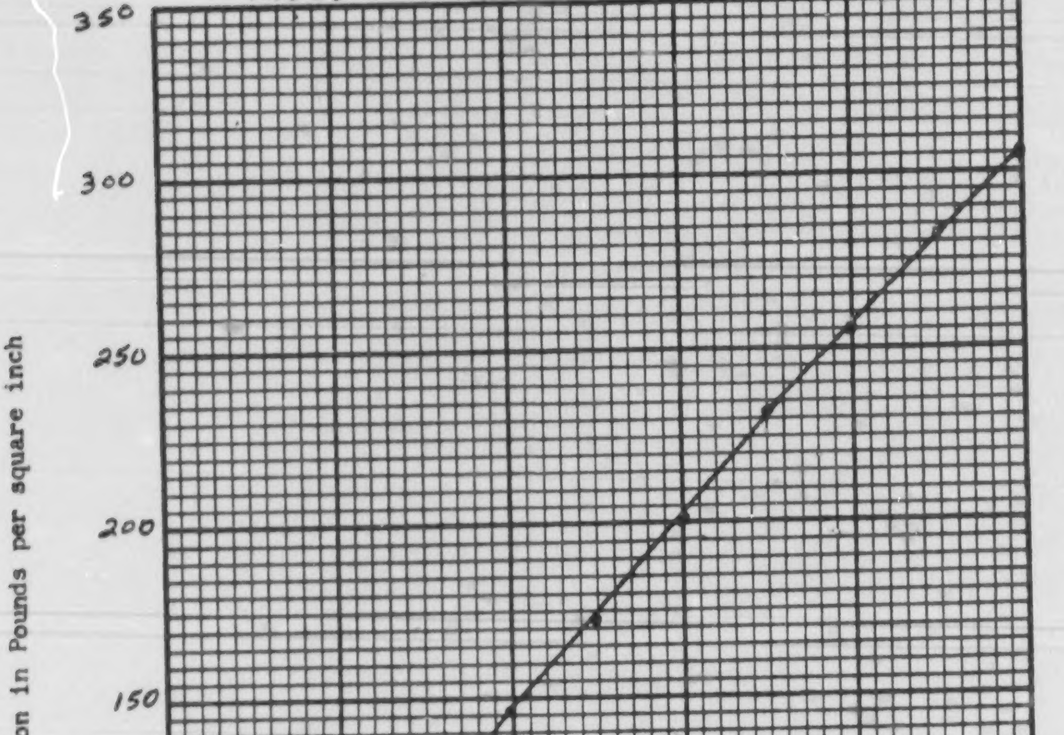
GR#5
STD
1450

Corrected Load @ 0.1 = 87.0 PSI

Corrected Load @ 0.2 = 150.0 PSI

MOLD# 14

55 BPL.



3- -25,830—Ft Belvoir

CALIFORNIA BEARING RATIO

PENE. inches	TIME minutes	STAND. LOAD p.s.i.	Gage Readings 15			Test Load 15 Lbs.			Test Load 15 Psi			Corrected Test Load 15 PSI			C B R in 15 %		
			55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows
0.025	0.5		.00035			35			11.7								
0.050	1.0		.00085			85			28.3								
0.075	1.5		.0014			140			46.7								
0.100	2.0	1000	.0019			190			63.3			77.0			7.7		
0.125	2.5		.00245			245			81.7								
0.150	3.0		.00290			290			96.7								
0.175	3.5		.0033			330			110.0								
0.200	4.0	1500	.00385			385			128.3			140.0			9.3		
0.250	5.0		.0046			460			153.3								
0.300	6.0		.0054			540			180.0								
0.350	7.0		.0063			630			210.0								
0.400	8.0		.0071			710			236.7								
0.450	9.0		.0078			780			260.0								
0.500	10.0		.00845			845			281.7								

SWELL DATA

Date	Time in Days, Hours or Minutes			Gage Reading 15			Swell in Inches			Swell in %					
	55/B	26/B	12/B	55/B	26/B	12/B	55/B	26/B	12/B	55/B	26/B	12/B			
8 OCT 1974	4 DAYS			93.3			.0933			1.87					

[illegible]

SCBT 440.2A EA IS 1.2.8.1

225

Heavy Construction Branch, Dept. of Engr. & Mil. Science GR#5 STA 11+50

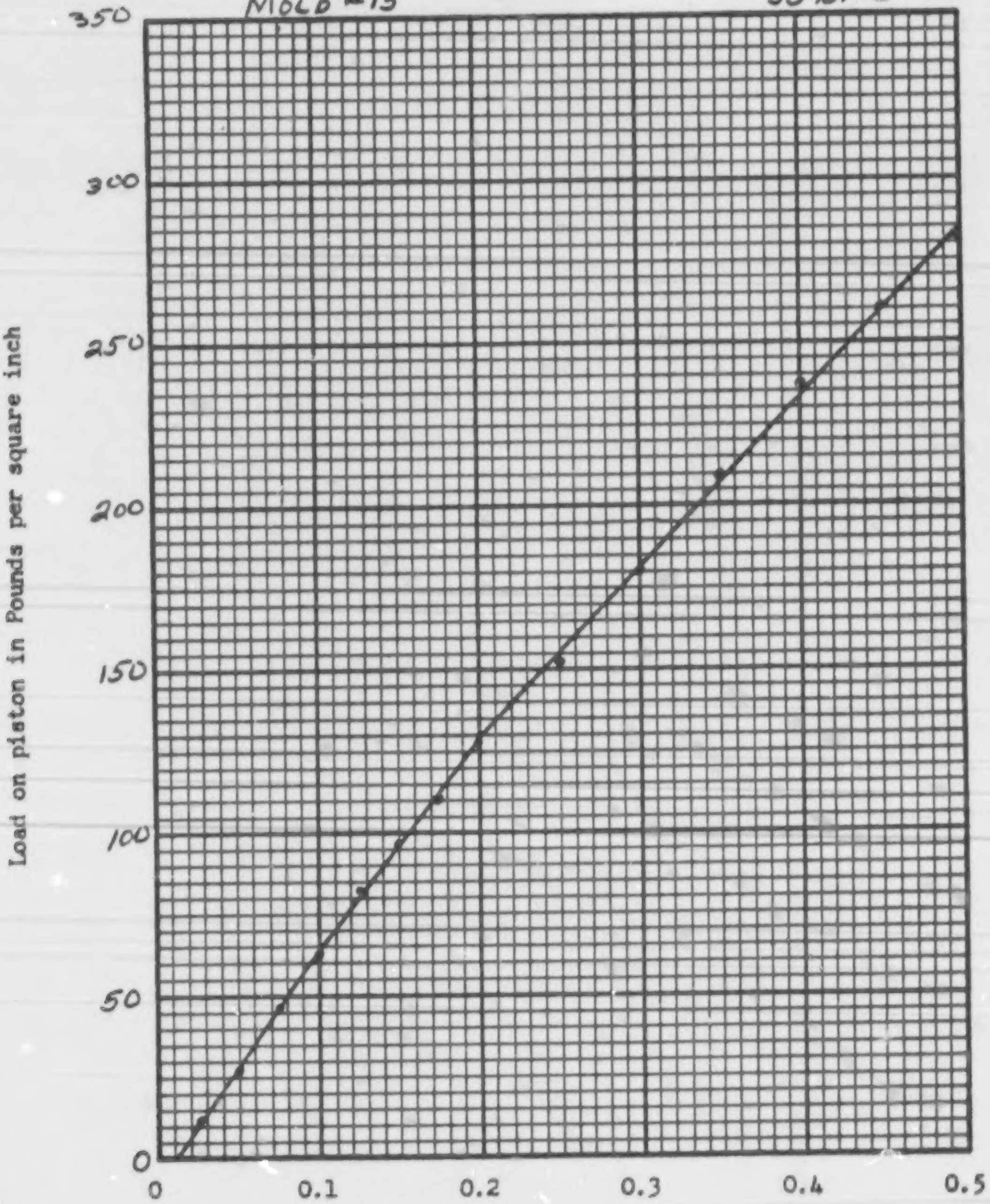
CBR VERIFICATION GRAPH

Corrected Load @ 0.1 = 77.0 **PSI**

Corrected Load @ 0.2 = 140.0 **PSI**

Mold #15

55 BPL



Penetration in inches

SCBT 440.2A EA IS 1.2.8.1

CALIFORNIA BEARING RATIO

PENE. inches	TIME minutes	STAND. LOAD p.s.i.	Gage Readings 16			Test Load 16 Lbs.			Test Load 16 Psi			Corrected Test Load 16 PSI			C B R 16 %		
			55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows	55 Blows	26 Blows	12 Blows
0.025	0.5		.0002			20			6.7								
0.050	1.0		.0009			90			30.0								
0.075	1.5		.00165			165			55.0								
0.100	2.0	1000	.0024			240			80.0			100.0			10.0		
0.125	2.5		.0033			330			110.0								
0.150	3.0		.0041			410			136.7								
0.175	3.5		.0049			490			163.0								
0.200	4.0	1500	.0057			570			190.0			205.0			13.7		
0.250	5.0		.0072			720			240.0								
0.300	6.0		.0084			840			280.0								
0.350	7.0		.0095			950			316.7								
0.400	8.0		.0110			1100			366.7								
0.450	9.0		.0120			1200			400.0								
0.500	10.0		.0135			1350			450.0								

SWELL DATA

Date	Time in Days, Hours or Minutes 16			Gage Reading 16			Swell in Inches 16			Swell in % 16					
	55/B	26/B	12/B	55/B	26/B	12/B	55/B	26/B	12/B	55/B	26/B	12/B			
8 OCT 1974	4 DAYS			93.0			.093			1.86					

GE 53
570.11760

SCBT 440.2A EA IS 1.2.8.1

Heavy Construction Branch, Dept. of Engr. & Mil. Science

CBR VERIFICATION GRAPH

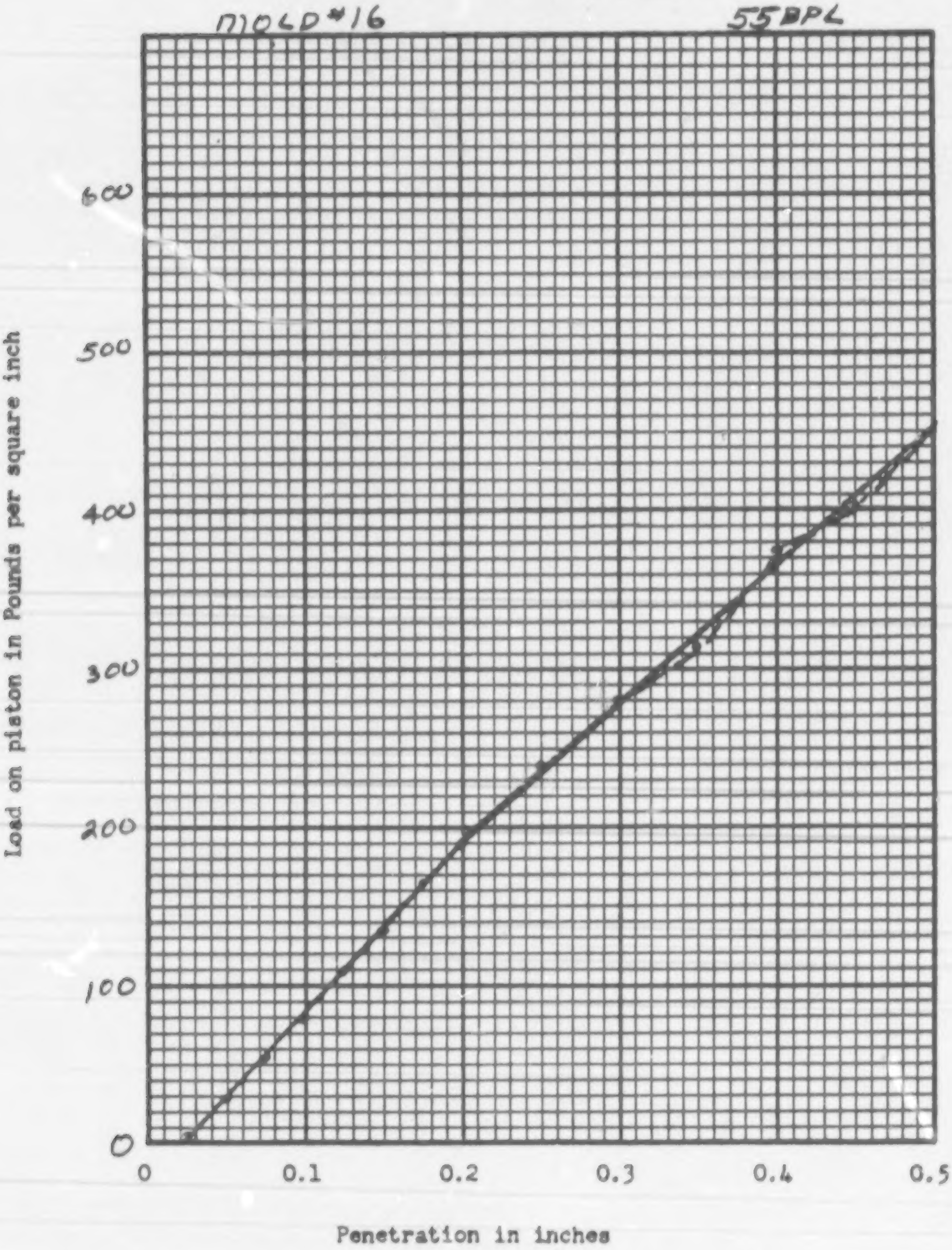
GA#5
STA
11+50

Corrected Load @ 0.1 = 100.0 PSI

Corrected Load @ 0.2 = 205.0 PSI

MOLD #16

55 BPL



SCBT 440.2A EA IS 1.2.8.1

CBR FAMILY OF CURVES DATA SHEET

ω(%)		55 BLOWS/LAYER	26 BLOWS/LAYER	12 BLOWS/LAYER
14	γ_d	110.0 LBS/FT^3	98.0 LBS/FT^3	— LBS/FT^3
	CORR. CBR	7.5 %	4.5 %	— %
15	γ_d	110.0 LBS/FT^3	100.5 LBS/FT^3	— LBS/FT^3
	CORR. CBR	11.6 %	5.25 %	— %
16	γ_d	111.0 LBS/FT^3	102.5 LBS/FT^3	— LBS/FT^3
	CORR. CBR	14.0 %	6.25 %	— %
17	γ_d	111.5 LBS/FT^3	104.3 LBS/FT^3	94.0 LBS/FT^3
	CORR. CBR	15.6 %	7.5 %	3.0 %
18	γ_d	113.0 LBS/FT^3	105.5 LBS/FT^3	95.5 LBS/FT^3
	CORR. CBR	16.5 %	9.1 %	4.25 %
19	γ_d	111.5 LBS/FT^3	106.0 LBS/FT^3	98.0 LBS/FT^3
	CORR. CBR	15.75 %	10.2 %	4.7 %
20	γ_d	109.4 LBS/FT^3	104.8 LBS/FT^3	100.0 LBS/FT^3
	CORR. CBR	14.0 %	10.6 %	5.0 %
21	γ_d	106.7 LBS/FT^3	103.8 LBS/FT^3	101.0 LBS/FT^3
	CORR. CBR	11.5 %	10.5 %	4.5 %
22	γ_d	105.0 LBS/FT^3	103.0 LBS/FT^3	100.25 LBS/FT^3
	CORR. CBR	9.75 %	10.4 %	3.3 %

STA. 11+50

GROUP #5

PROJECT ______________________

SOIL CLASSIFICATION ______________________

LOCATION OF SOIL ______________________

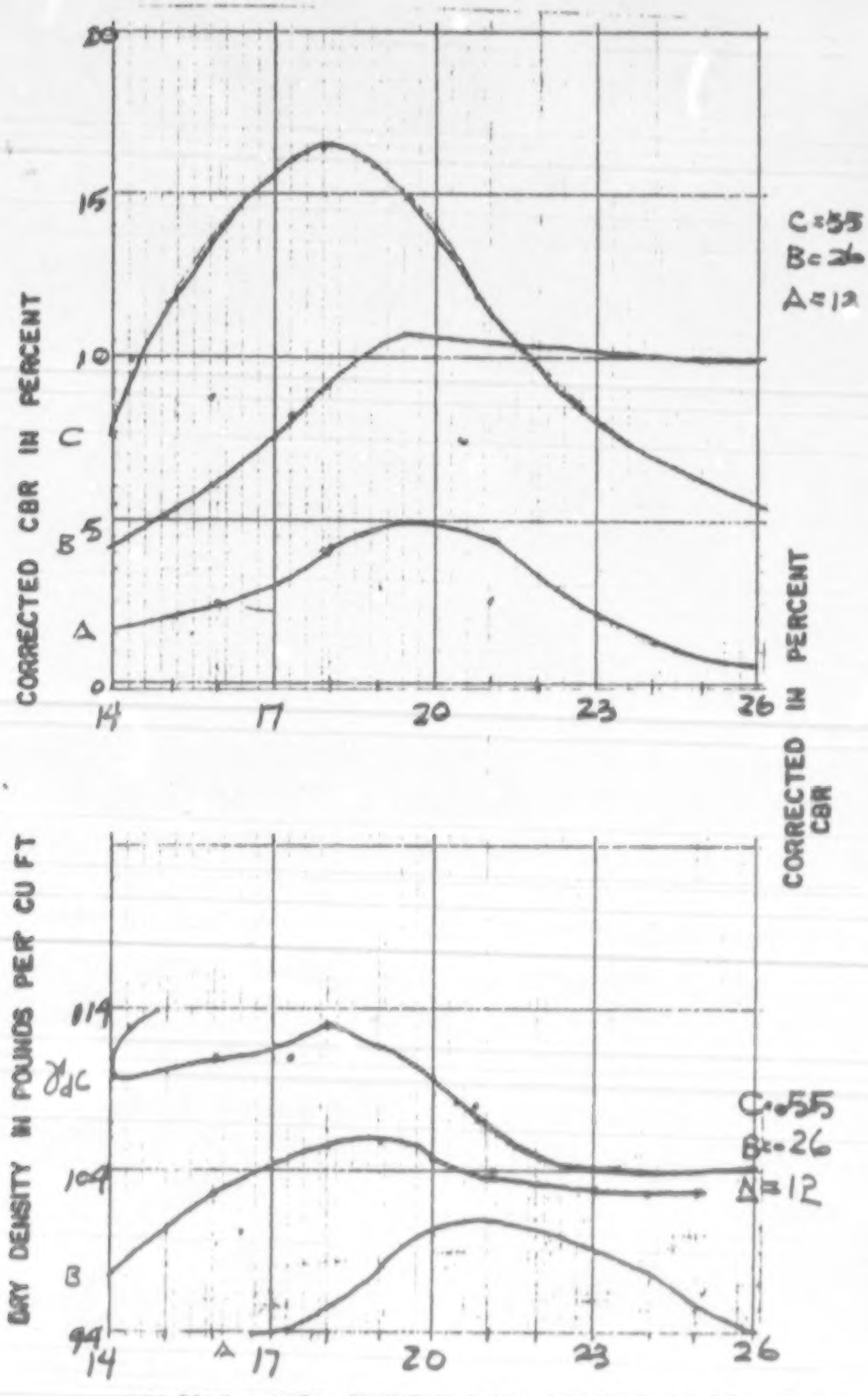
DATE OF TESTS ______________________

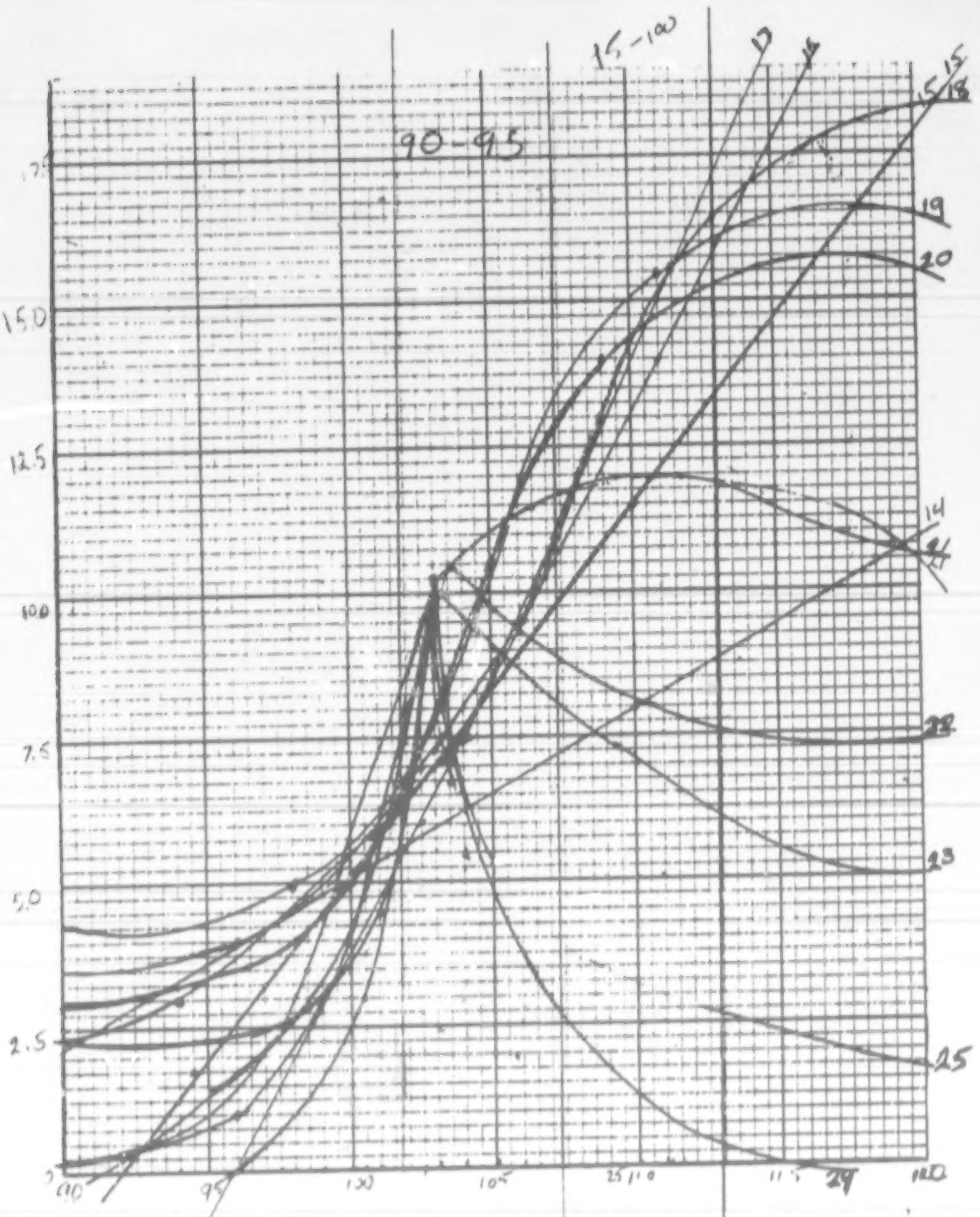
GROUP # ______________________

NAME ______________________

DATA SUMMARY

MOLD #	BLOWS PER LAYER	MOISTURE CONTENT ω %	DRY DENSITY γ_d	CORRECTED CBR %
1	55	20.8	108.34	12
4	55	17.4	111.77	8.25
7	55	20.5	108.2	7.5
10	55	21.3	104.8	2.7
13	55	17.9	113.39	16.5
15	55	14.05	110.88	7.7
16	55	14.3	113.61	10
14	55	16.23	111.11	8.7
2	26	17.91	106.73	9
5	26	[illegible]	103.7	11.2
8	26	[illegible]	103.14	10
11	26	[illegible]	103.83	3
17	26	17.89	108.3	8.25
3	12	17.72	95.65	4.15
6	12	16.05	99.67	2.6
9	12	19.56	100.38	3
12	12	21.76	101.08	4.5
18	12	25.34	94.83	.91


CORRECTED CBR IN PERCENT
20
15
10
5
0
C
B
A
14
17
20
23
26
C=55
B=26
A=12
CORRECTED CBR IN PERCENT
DRY DENSITY IN POUNDS PER CU FT
114
γ_{dC}
104
B
94
A
14
17
20
23
26
C=55
B=26
A=12
MOLDING WATER CONTENT (W) IN PERCENT OF DRY WEIGHT



MOLDED DRY DENSITY IN POUNDS PER CU FT

-46,490—Ft Belvoir

CONCLUSIONS AND RECOMMENDATIONS

A: The soil investigation by this group has been found to be not well suited for a subgrade material. In fact it is a low compressive clay and not stable enough to support the live and dead weights of aircraft. Moisture content is relatively high and thus poor drainage will result.

B. The CL layer is not very deep and varies from station to station, and it is recommended that this layer not be removed due to a high water table for the area concerned.

C. If this ares is to be used to support an airfield it is highly advisable that some type stabilzing material such as lime be used to help stablize the CL layer used for the subgrade. This can be accomplished by runnung tests on the soil and using lime in proportions until the proper amount of additive can be determined for the entire project.

D. A good sand, clay, gravel mixture should be used over the CL layer to give extra strength to the subgrade and sub base layers and to insure the finished surface will be durable and long lasting.

E. It is the personal opinion of this group that another site be looked into for the construction of such an airfield that in the long run would insure less loss of manpower and equipment in getting the job done.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
SPECIAL CONSTRUCTION BATTALION TRAINING (SCBT) 440.2A

Classification: Unclassified

Topic: Soils Stabilization Agents

Average Time: 2 Periods (Class), 2 Periods (Pract)

Instructional Materials:

A. Texts:

1. NAVFAC MO-330, Material Testing, 1971.

B. References:

1. Soil Cement Construction Handbook, Portland Cement Association.

C. Tools, Equipment and Materials:

1. See Annex III of Curriculum.

D. Training Aids and Devices:

1. Films: None.

2. Transparencies: None.

3. Charts: None.

4. Locally Prepared Materials:

a. Job Sheets.

(1) SCBT 440.2A EA JS 1.2.9.1, "Stabilization Agents".

Terminal Objective: Upon completion of this unit each student will have explored, identified, classified and stabilized soils. Conditions, standards and procedures for each of the related topics leading to the successful completion of this terminal objective shall be as set forth in each topic.

Enabling Objectives: Upon completion of this topic each student while working as a member of a team (not to exceed four (4) members) will be able to select a stabilizing agent by using the agents characteristics as they apply to a given unstable soil condition. The characteristics used must be in accordance with this instructor guide and NAVFAC MO-330, Material Testing. All responses will be as a team and four (4) correct out of a possible five (5) responses by each team will be considered satisfactory achievement for each student.

Criterion Test: Each student while working as a member of a team (not to exceed four (4) members) will select stabilizing agents using their characteristics for five (5) different sets of unstable soil conditions. All work will be as a team and a minimum of four (4) out of a possible five (5) correct responses by each team will be considered satisfactory achievement for each student. All responses must be in accordance with this instructor guide and NAVFAC MO-330, Material Testing.

Homework: Read NAVFAC MO-330, Material Testing, Chapter 5, para. 5-1 to 5-5.

E. Training Aids Equipment: None.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to the lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name:		
2. Topic: Soils Stabilization Agents		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
a. Pass course.		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better quality control technician.		
D. Overview.	I.D. State learning objectives.	
1. You will be able to select stabilizing agents for soils by their characteristics and thus stabilize an unstable soil condition.	1. State information and materials necessary to guide student.	
2. Ask questions.		
3. Take notes.		
4. Testable.		

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

II. Presentation.

A. What is soil stabilization?

1. Soils stabilization is the process which alters any property of the soil to improve its engineering characteristics.

2. Two main types.

a. Cementing action.

(1) Results in a hardened product of considerable strength.

b. Modification.

(1) Results in an improvement of some soils properties or in the elimination of some undesirable features in a soil.

(2) The end product may or may not show an improved strength.

3. Soils stabilization is used to provide improved subgrade and base course characteristics.

a. For pavements.

b. Can be used as light traffic pavements.

c. For parking areas.

d. For storage areas.

e. An all weather surface.

OUTLINE OF INSTRUCTION INSTRUCTOR ACTIVITY STUDENT ACTIVITY

II. Presentation.

A. What is soil stabilization?

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3. Soils stabilization is used to provide improved subgrade and base course characteristics.

a. For pavements.

b. Can be used as light traffic pavements.

c. For parking areas.

d. F[illegible] storage areas.

e. An all weather surface.

f. Dust control.

g. Helo pads.

h. Etc.

B. Stabilized soils and agents.

1. Soil cement - highly compacted mixture of pulverized soil, portland cement and water; used since 1920's.

a. Cement used:

(1) Any portland that complies with ASTM, AASHO, USASI.

(2) Type 1 and 1A most commonly used.

b. Water to be potable whenever possible.

c. Soil - preferably granular non-plastic material.

(1) In-place.

(2) Imported to site.

d. Chemical reaction - hydration.

e. Physical change - rigid plane.

f. Major uses:

(1) Base course for -

(a) Roads and streets.

(b) Runways and taxiways.

(c) Parking and storage areas.

(2) Sub-base for:

(a) Concrete paving.

(b) Soil-cement paving.

(c) Flexible pavements.

(3) Treated sub-grade.

(4) Other uses:

(a) Dam facings.

(b) Resevoir linings.

(c) Ditch and canal lining.

g. Usually topped with an asphalt seal or wearing surface.

2. Cement-modified soil.

a. Small amount of portland cement used.

b. Retains properties of soil, but improved.

(1) Plasticity reduced.

(2) Water retention reduced.

(3) Volume change capacity reduced.

(4) Bearing value and shear strength increased.

3. Lime - soil - compacted mixture of pulverized soil, lime and water; used in Tibet 5000 years ago and by Romans as sub-base on Appian Way.

   a. Lime used.

      (1) Quicklime (calcium oxide -(AO)).

      (2) Hydrated lime (Calcium Hydroxide-CA $(OH)_2$).

      (3) Not usable is pulverized limestone.

         (a) Deficient in proper oxides which cause chemical reaction with water.

   b. Water potable when possible.

   c. Mainly used with clay-bearing soils and gravels.

      (1) 10 - 50 P.I.

      (2) 3% - organic matter.

      (3) Not beneficial to silts and clays.

   d. Chemical reaction.

      (1) Agglomerates (gather together) fine clay particles into coarse friable particles (silt and sand sizes) through a phenomena called base exchange.

(a) "Cementing" action continues for 1 year or more.

e. Physical effects on soil.

(1) P.I. drops sharply - P.L. increases/L.L. decreases.

(2) Disintegration accelerated.

(3) Soil binder content decreases.

(4) Drying of soil in swamp or over OMC areas.

(5) Shrink & swell differntial decreases.

(6) Unconfined compressive strength increases - none to 40 times.

(7) CBR values increase.

(8) Water resistant "working table" formed.

(a) Impedes and sheds gravity water.

(b) Prevents capillary rise of ground water.

f. Uses.

(1) Base.

(a) Soil must be 50+% coarse material.

(b) Gives paving platform.

(2) Sub-base.

(a) Soil is material such as hydraulic clay fill.

(3) Subgrade.

(a) Soil is in-place (in-situ) fine grained materials.

4. Lime-modified soil.

a. Upgrading fine grained or granular materials with small amount (3% or less) of lime.

b. No credit accorded the modified layer for road design.

(1) No reduction to pavement design thickness.

5. Soil-asphalt.

a. Types of asphalt used - cutbacks.

(1) R.C. - grade 70 - 800.

(2) M.C. - grade 70 - 800.

b. Types of soil.

(1) Sandy soils - minimum amount silts & clays.

(a) Not over 30% of -200 and/or.

(b) P.I. over 10.

(c) Use M.C.

c. Primary function - expedient construction.

(1) Waterproofer.

(2) Dust palliative.

(3) Strength & improvement not factors.

d. General rules on usage.

(1) Use only with soils that can be readily pulverized by mix-in-place equipment.

(2) Use the heaviest asphalt that can be readily worked into the soil, considering:

(a) Equipment available.

(b) Weather.

1. Work during warmest weather possible.

e. Disadvantages.

(1) Comparatively large quantities of bitumens required.

(2) Range of soil types effectively stabilized is limited.

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(3) Ultimate results dependent upon strict adherence to mix design.

(4) Long curing time usually required.

6. Calcium Chloride ($C_a Cl_2$).

a. Properties.

(1) Deliquescent - absorbs moisture and desolves.

(2) Hygroscopic - attracts moisture.

(3) Moisture film and surface tension stronger than water.

(4) Vapor pressure lower than water.

(a) Less evaporation even in low humidity or high temperatures.

(5) Low freezing point in solution.

b. Soils - dry.

(1) Granular.

(2) Non-plastic.

c. Resultant advantages from use.

(1) Increased density, through:

(a) Surface tension.

(b) Lubrication.

(c) Moisture film.

(2) Less compaction required.

  (a) Approximately 2/3 to 1/2 less passes of equipment.

(3) Uniform moisture control.

  (a) Maintain OMC for % density required.

  (b) Less evaporation.

    1. Low vapor pressure.

    2. Replenishment after sundown.

(4) Less binder required.

  (a) Moisture retention keeps fines in place.

(5) Controlled curing for increased stability.

  (a) Uniform drying prevents dry top layer while bottom layer still moist.

(6) Surface uniformity.

  (a) Graders can be used during initial rolling without fear of excessive evaporation.

(7) Dustfree surface.

  (a) Prevents loss of material to wind.

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(b) Less need for watering.

1. Equipment not tied up.

(c) More compatible working conditions.

(8) Improved bond.

(a) Better absorption of bitumens.

1. No blockage by dust film.

2. Wetting before priming not required.

(b) Stronger adherence by bitumens to materials for full depth.

(9) Frost protection against heaving.

(a) Percentage by weight.

1. Well graded soil - .5%.

2. Silts - 2%.

3. Clayey - 1%.

d. Uses.

(1) Wearing surface for indefinite period.

(2) Base course for immediate bituminous surfacing.

(3) Wearing surface for short period before bituminous surfacing.

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

(4) Stage construction.

(a) Grade and drain.

(b) Light surfacing of aggregate.

(c) Stabilized aggregate wearing surface.

1. Dust free and compacted for future improvement.

2. Less gravel loss.

3. Fewer bladings during maintenance.

(d) Bituminous or concrete pavements.

7. Salt-sodium chloride (N_aCl).

a. Results of controlled usage of salt and water.

II.B.7. Roman writings tell of traffic passing over spilled salt resulted in harder surface and reduced dust.

(1) Stabilization.

(2) Greater load bearing capacity.

(3) Reduced maintenance.

b. Applications.

(1) Wearing course.

(a) Traffic-bound roads.

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1. Where traffic does compaction.

(b) Secondary roads.

1. Farms.

2. Rural.

3. Highway feeders.

4. Recreation access.

(2) Base for primary roads.

(3) Sub-base and shoulders on secondary roads.

c. Interactions between soil and salt.

(1) Extreme densities & imperviousness through.

(a) Binding with natural clays in soils.

(b) Retains water during compaction.

(c) Recrystallizes and fills natural voids.

1. Prevents shrinkage.

2. Maintain density after drying.

(d) Lowers freezing point.

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8. Crushed lime rock.
    - a. Uses:
        - (1) Crushed base rock fill.
        - (2) Filler.
        - (3) Not a substitute for lime-soil.
        - (4) Use mechanical stabilization whenever possible before costly chemical stabilization.

9. Sand.
    - a. Use as stabilizer of clay materials.
        - (1) expedient.
        - (2) Blanket course between base and plastic subgrade.
        - (3) Make trial design section.

C. Factors in selection of stabilizing agents.

1. Soil type.
    - a. Graduation.
        - (1) Well graded.
        - (2) Uniform.
        - (3) Gap.
    - b. Gravel, sand, silt, clay

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OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

c. Moisture content.

2. Climatic conditions.
    a. Arid/humid.
    b. Rain/snow.
    c. Winds.
    d. Frost action.
    e. Temperatures.
3. Equipment availability.
    a. Digging.
    b. Crushing.
    c. Hauling.
    d. Mixing.
    e. Spreading.
    f. Grading.
    g. Compacting.
    h. Paving.
4. Manpower.
    a. Numbers.
    b. Experience
5. Time factor.

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a. Allotted time for project.

b. Delivery of equipment or material.

c. Weather closing in.

  (1) Rain - monsoons.

  (2) Snow.

  (3) Freezing temperatures.

d. Experience of personnel.

e. Working hours available.

  (1) Daylight.

  (2) Nightlighting.

6. Expected load limit.

a. Class of road.

  (1) Main.

  (2) Secondary.

b. Type of vehicles.

  (1) Hauling.

  (2) Personnel.

  (3) Armored.

    (a) Wheeled.

    (b) Tracked.

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OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

c. Surface.

(1) Compacted.

(2) Paved.

d. Duration.

(1) Temporary.

(2) Permanent.

7. Available stabilizer.

a. Mechanical agents.

(1) Rock.

(2) Sand.

(3) Soil.

b. Chemical agents.

(1) Calcium Chloride.

(2) Calcium Oxide.

(3) Calcium Hydroxide.

(4) Sodium Chloride.

c. Cementing agent.

(1) Portland cement.

(2) Asphalt bitumens.

- (a) Palliative.
- (b) Water seal.

d. Limitations.

- (1) Aids to construction.
- (2) Interims for stage construction.
- (3) Not replacement for optimum design.
- (4) Laboratory design required.
    - (a) Prevent useless effort.
    - (b) Prevent waste of materials.
    - (c) Prevent tie-up of equipment.

D. Safety factors.

1. Cement.

a. Chemical burns.

- (1) Perspiration.
- (2) Inhalation.

2. Quicklime.

a. Chemical burns.

- (1) Perspiration.
- (2) Inhalation.

OUTLINE OF INSTRUCTION | **INSTRUCTOR ACTIVITY** | **STUDENT ACTIVITY**

3. Asphalt cutback.
    a. Chemical burns.
        (1) Skin contact.
4. Calcium Chloride & Sodium Chloride.
    a. Corrosive to materials.

III. Application.

A. Discussion.

III.A. Questions.	III.A. Answers.
1. Name the two main types of stabilization agents.	1. Cementing action and modification.
2. Soil cement is composed of what?	2. Soil. cement and water.
3. Cement-modified soil uses portland cement to do what to the plasticity of a soil?	3. Reduce it.
4. What type lime is not useable as a stabilizing agent?	4. Limestone.
5. Name three functions of asphalt in soil-asphalt.	5. Waterproofer, dust palliative, expedient construction.
6. What type soil would you use Calcium Cholride on?	6. Soils - dry, granular and non-plastic.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVI
	7 Salt has what three results under controlled usage?	7. Stabilization, greater load bearing capacity, reduced maintenance.
B. Practical performance.	III.B. Read and explain the criterion test. Pass out Job Sheet SCBT 440.2A EA JS 1.2.9.1, "Stabilization Agents", and explain.	III.B. Fulfill the requirements of the criterion test and Job Sheet SCBT 440.2A EA JS 1.2.9.1.
IV. Summary.	Solution to problems.	
A. What is soil stabilizations?	a. Cement.	
B. Stabilized soils and agents.	b. Lime.	
C. Factors in selection of stabilizing agents.	c. Calcium Chloride.	
D. Safety factors.	d. Asphalt.	
V. Test.	e. Cement.	

SCBT 440.2A EA JS 1.2.9.1

NAVAL CONSTRUCTION TRAINING CENTER
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JOB SHEET

Title: Stabilization Agents.

Introduction: The following practice problems are used to evaluate your understanding of stabilization agents as they apply to soils. You will work these problems as a team and all responses will be made as a team. Thus, further reinforcing your understanding of this subject matter.

References:

1. NAVFAC MO-330, Material Testing.

Tools and Equipment:

1. Pencils and paper.

Materials:

1. None

Procedures:

1. You will as a team discuss each situation presented.
2. After your team has discussed all five situations submit your team report for discussion with your instructor.

Questions:

1. None

Problems:

1. Laboratory test data shows a granular non-plastic soil in-place which is intended as a parking lot. The surface pavement will be of a flexible type.

   Recommended agent__________________________________.

2. Laboratory test data shows a soil with 50+% coarse material which is to be used as a base for paving. The design requirements make it necessary to improve the CBR values and prevent capillary rise of ground water.

   Recommended agent __________________________________.

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3. Laboratory test data shows a dry, granular non-plastic soil on which you want to put a Bituminous surface immediately. This means a dust free working surface, less compactive effort required, improved surface uniformity and working conditions.

   Recommended agents ______________________________________.

4. Laboratory test data shows a sandy soil with P.I. of less than 10. Due to the expedient nature of construction, we must use the in-place soil.

   Recommended agent ______________________________________.

5. Laboratory test data shows a granular non-plastic soil in-place. In order to meet design requirements we must first improve the following soil characteristics: (1) Reduce its plasticity, (2) Reduce its water retention, and (3) Improve its bearing value and shear strength.

   Recommended agent ______________________________________.

NAVAL CONSTRUCTION TRAINING CENTER
PORT HUENEME, CALIFORNIA 93043
SPECIAL CONSTRUCTION BATTALION TRAINING (SCBT) 440.2A

Classification: Unclassified

Topic: Soil Stabilization (Design Procedures and Control)

Average Time: 1 Period (Class)

Instructional Materials:

A. Texts:

1. NAVFAC MO-330, Material Testing.

B. References:

1. Soil Cement Construction Handbook, Portland Cement Association.

C. Tools, Equipment and Materials:

1. See Annex III.

D. Training Aids and Devices.

1. Films:

   a. SOI001 Soil - Cement Inspection and Field Control, 20 min.

2. Transparencies: None

3. Charts: None

4. Locally Prepared Materials: None

Terminal Objective: Upon completion of this unit each student will have explored, identified, classified and stabilized soils. Conditions, standards and procedures for each of the related topics leading to the successful completion of this terminal objective shall be as set forth in each topic.

Enabling Objective: Upon completion of this topic each student will be able to discuss soil stabilization design procedures and field application control as set forth in NAVFAC MO-330, Material Testing. Student will answer questions orally and as a group with 100% accuracy as developed by the instructor. This topic is not intended to be restrictive.

Criterion Test: Each student will be able to discuss soil stabilization design procedures and field application control as set forth in NAVFAC MO-330, Material Testing. Student will answer questions orally and as a group with 100% accuracy as developed by the instructor. This topic is not intended to be restrictive.

Homework: Read: MO-330, Material Testing. Chapter 5, All.

E. Training Aids and Equipment

1. 16mm Projector

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
I. Introduction to he lesson.		
A. Establish contact.	I.A. Introduce self and topic.	
1. Name.		
2. Topic: Soil Stabilization (Design Procedures and Control)		
B. Establish readiness.	I.B. Motivate student.	
1. Purpose.		
2. Assignment.		
C. Establish effect.	I.C. Bring out need and value of material being presented.	
1. Value.		
2. a. Pass course		
b. Perform better on the job.		
c. Get advanced.		
d. Be a better Quality Control Technician.		
D. Overview:	I.D. State learning objective.	
1. You will be able to discuss soil stabilization design procedures and field application control.	a. State information and material necessary to guide student.	
2. Ask questions		
3. Take notes		

OUTLINE OF INSTRUCTION | INSTRUCTOR ACTIVITY | STUDENT ACTIVITY

II. Presentation

A. Strength requirements and use of Area

B. Type of Area

1. Road.
2. Airfield.
3. Storage Facility.
4. Etc.

C. Availibility of Materials.

D. Soil - Cement Procedures.

1. Soil sampling and preparation.
2. Soil; identification tests.
3. Moisture density test.
4. Determine cement requirements by charts and lab tests.
5. Compressive - strength tests.
6. Wet - dry or freeze-thaw tests.
7. Pick and click tests.

E. Asphalt - Soil Procedures.

1. Soil sampling and preparation.

2. Soil identification tests.

3. Determine type and grade of liquid asphalt by chart.

4. Determine asphalt requirements by Lab tests.

5. Compressive - strength test.

F. Lime-soil Procedures.

1. Soil sampling and preparation.

2. Soil idemtification tests.

3. Selection of type of lime.

   a. Hydrated.

   b. Quicklime.

4. Moisture density tests.

5. Compressive - strength tests.

G. Field Testing.

1. Inspection of site preparation.

   a. Identification of soils.

   b. Grading, crown and soft spots check.

OUTLINE OF INSTRUCTION	INSTRUCTOR ACTIVITY	STUDENT ACTIVITY
2. Inspection of Processing Operations.		
a. Pulverization.		
b. Control of stabilizing agent.		
(1) Control of application.		
c. Moisture content control.		
d. Compaction and moisture - density tests.		
e. Construction joints check.		
f. Degree of compaction and depth check.		
g. Sealer or moisture retaining cover check.		
III. Application		
A. Discussion - To be developed by the instructor.	III.A. Questions	III.A. Answers
B. Practical Performance.		
1. None		

OUTLINE OF INSTRUCTION INSTRUCTOR ACTIVITY STUDENT ACTIVITY

IV. Summary

- A. Strength.
- B. Type of Area.
- C. Avilibility of Materials.
- D. Soil - Cement Procedures.
- E. Asphalt - Soil Procedures.
- F. Lime - Soil Procedures.
- G. Field Testing.

V. Tests.

- A. None.